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THE

BOOK of NATURE;

OR, THE

HISTORY OF INSECTS:

Reduced to diſtinct CLASSES, confirmed by particular INSTANCES,
Diſplayed in the Anatomical Analyſis of many SPECIES,

AND

ILLUSTRATED with COPPER-PLATES.

INCLUDING

The Generation of the FROG, the Hiſtory of the EPHEMERUS, the Changes of FLIES,
BUTTERFLIES, and BEETLES;

WITH THE

Orginal Diſcovery of the MILK-VESSELS of the CUTTLE-FISH, and many other curious Particulars.

By JOHN SWAMMERDAM, M. D.

WITH

The LIFE of the AUTHOR, by HERMAN BOERHAAVE, M. D.

Tranſlated from the DUTCH and LATIN Original Edition,

By THOMAS FLLOYD.

Reviſed and improved by NOTES from REAUMUR and others,

By JOHN HILL, M. D.

J.C.G. Fritsch sc. Lips.

LONDON:
Printed for C. G. SEYFFERT, Bookſeller, in DEAN-STREET, SOHO.
MDCCLVIII.

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To the RIGHT HONOURABLE

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EARL OF MACCLESFIELD,

PRESIDENT

OF THE ROYAL SOCIETY,

This WORK

Is moſt Humbly Inſcribed,

By His LORDSHIP'S

Moſt Devoted Humble Servant,

The EDITOR.

THE

LIFE

OF

JOHN SWAMMERDAM.

JAMES Theodorus was born in Swammerdamme, a village of Holland ſituated upon the Rhine, between Leyden and Woerden; and removing afterwards to Amſterdam, where he carried on the timber trade, obtained the ſurname of Swammerdam from the place of his nativity. In this laſt place heaven bleſſed him on the laſt day of January in the year MDCVI, with a ſon, who was called John James Swammerdam, who followed in that famous city the buſineſs of an apothecary. As this John was very ſtudious of natural hiſtory, and very well ſkilled in ſeveral branches of it, ſo he diligently improved every opportunity of cultivating it, which his reſidence and way of life afforded; and for fifty years together ſpared neither pains or expence in procuring proper materials for that purpoſe. And indeed his collection was very magnificent, his houſe being full of animals, inſects eſpecially, vegetables, and foſſils, though without the leaſt confuſion, every thing being diſpoſed in its proper place and order. But the chief ornaments of his muſeum were curioſities from both the Indies, and particularly the porcelain of China and Japan. Both citizens and ſtrangers viewed this collection with admiration; and the greateſt princes, that paſſed through Amſterdam, viſited it, as one of the things beſt worth their attention in that famous city. Many of theſe, delighted with the ſight of ſo beautiful a ſpectacle, offered to purchaſe it, but were ſurpriſed at the price, the poſſeſſor valuing it at ſixty thouſand Dutch florins; though after his death, when his curioſities were ſold publickly in ſingle lots, they ſcarce fetched one ſixth of that price.

This great naturaliſt, and Barentje Corver, daughter of John Janſz Corver, were the parents of John Swammerdam, who was born at Amſterdam the twelfth of February MDCXXXVII, and lived to be the celebrated author of this valuable work.

His father intended him for the church, and with this view took care to procure him early inſtructions in Latin and Greek; but our author, after a ſerious examination of his own diſpoſition and talents, thought himſelf unequal to ſo important a taſk, and brought his father to change his former intention, who thereupon conſented to his ſon's applying himſelf to phyſic; but as he kept him at home till he ſhould be properly qualified to engage in that ſtudy, he frequently employed him in cleaning his curioſities, and putting every thing in its proper place. This occupation inſpired our author in a manner from his childhood, with a taſte for natural hiſtory, ſo that not content with the ſurvey of thoſe curioſities that his father had purchaſed, he ſoon began to make a collection of his own by catching ſome, and buying or bartering for others, all which he diſpoſed in certain claſſes; and compared with the accounts given of them by the beſt writers. However, when grown up, he very ſeriouſly attended to his anatomical and medical ſtudies, but all the while with a mind bent on attempts of the greateſt importance. Accordingly he ſpent both day and night in diſcovering, catching, and examining, the flying inſects proper to thoſe two different times, not only in the province of Holland, but in that of Gueldres, and in the the province of Utrecht. He ranſacked with this view the air, the land, and the water; fields, meadows, paſtures, corn grounds, downs, waſtes, ſand hills; rivers, ponds, wells, lakes, ſeas, and their ſhores and banks; trees, plants, ruins, caves, uninhabited places, and even bog-houſes, in ſearch of Eggs, Worms, Nymphs, and Butterflies; in order to make himſelf acquainted with the neſts of inſects, their food, manner of living, diſorders, changes or mutations, and their ſeveral ways or methods of propagation; and, indeed, while yet a very young man, he had made more diſcoveries in regard to all theſe particulars, and obtained more certainty, than the known authors of all the preceding ages put together. This, however incredible it may appear to ſome, is notwithſtanding matter of fact. Perſons properly qualified to judge of his ſucceſs, have honoured it with the ſame teſtimony.

Our author, thus initiated in natural hiſtory, came to Leyden in the year MDCLI, to purſue his ſtudies in the Dutch univerſity, of which he was admitted a member the eleventh of October, and attended aſſiduouſly for two years together the lectures in ſurgery of the celebrated John Van Horne, and thoſe in phyſic of Francis Sylvius de la Boe; and his progreſs in thoſe noble ſtudies was ſo anſwerable to his diligence, that on the eleventh of October MDCLXIII, he was admitted a candidate of phyſic in that famous univerſity, after undergoing the examinations preſcribed on that occaſion. Our author, on his arrival at Leyden, contracted a friendſhip with that great anatomiſt Nicholas Steno, and ever after lived with him in the greateſt intimacy. He likewiſe commenced a friendſhip with Rynier de Graaf, another eminent anatomiſt; but emulation, or rather envy, afterwards changed it to an inveterate hatred. The curioſities of anatomy now began to make a conſiderable impreſſion on our author, formed it ſeems by nature herſelf for the cultivation and improvement of that noble ſcience; ſo that having gone through his courſes with the moſt ſudden and unexpected ſucceſs, he immediately began to conſider how the parts of the body prepared by diſſection, could be preſerved and kept in conſtant order and readineſs for anatomical demonſtrations; as ſuch a diſcovery would free him not only from the trouble of repeated diſſections, but likewiſe from the difficulty of obtaining freſh ſubjects, and the diſagreeable neceſſity of inſpecting ſuch as were already putrefied. And herein he ſucceeded, as he had done before, in his nice contrivances to diſſect and otherwiſe manage the minuteſt inſects. Sylvius, the moſt diligent anatomiſt of his time, made good uſe of this our author's great art and indefatigable induſtry; but was chiefly delighted at his extraordinary ſkill in diſſecting Frogs; for Swammerdam had demonſtrated to him by actual experiment, ſo early as the fifteenth of January of this year, that in this animal the air at the time of inſpiration could be derived to the artery and pulmonary vein, and thence to both regions of the heart. See Sylv. Diſp. Med. VII. §. LXXIX. — LXXXVIII.

After this our author made a journey into France, where he ſpent ſome time at Saumur, in the houſe of Tanaquil Faber, and made a variety of obſervations upon inſects. It was there, that on the nineteenth of June MDCLXIV, he diſcovered, by means of very ſlender tubes, the valves of the lymphatic veſſels, which he immediately ſent, on the twenty-eighth, delineated with his own hand, to his friend Steno, who he then thought reſided at Copenhagen. See his treatiſe on Reſpiration, page 90, 91. He afterwards wrote to Thevenot on the twenty-fourth of September in the year following, that perhaps the famous Frederick Ruyſh might have ſeen thoſe paintings before he publiſhed his own on the ſame ſubject: this he mentioned to Thevenot, on occaſion of his ſending him from Paris to Amſterdam, the little treatiſe on thoſe valves which Ruyſh publiſhed the ſame year at the Hague. But Swammerdam barely hinted this, without directly charging Ruyſh with plagiariſm, which he owns it is impoſſible for him to prove; on the contrary, he expreſſes a great deal of affection for his rival in this diſcovery, and ſays, he is ſincerely rejoiced at his having the honour of it. And no doubt Swammerdam did no more than juſtice to Ruyſh's merit on this occaſion, as this laſt, long before the edition of his book, had ſhewed theſe valves to others, and even to Bils. But the letters directed to Steno at Copenhagen, could not reach his hands in Holland, where he then reſided, but very late; and if Ruyſh had ſeen them, how could he have had the aſſurance to publiſh the drawings taken notice of, without mentioning Swammerdam, who was then living, and even on the ſpot. Among other things, our author, during his ſtay in the neighbourhood of the Loire, obſerved and deſcribed the flying inſect called Libella or Dragon Fly, and likewiſe ſome Hemerobia or Day Flies. From Saumur he went to Paris, where he lived in the ſame houſe, and in the greateſt friendſhip with Steno. He likewiſe contracted an intimacy with Melchiſedec Thevenot, a very worthy gentleman, and formerly the French king's miniſter at Genoa, who moſt hoſpitably received and entertained him and Steno at his pleaſant country ſeat of Yſſi, at a few miles diſtance from Paris, and thereby afforded our author an opportunity of making further obſervations upon the inſect creation. Not ſatisfied with this piece of politeneſs, he in conſideration of Swammerdam's ſingular abilities, and the great pains he had taken to cultivate them, made him a moſt liberal offer of every thing he thought requiſite to promote his ſtudies. Our author ever retained a grateful memory of thoſe favours, and others which he afterwards from time to time conſtantly received from this great reſpecter of merit; and a little before his death owns in one of his letters, that he had never found in any other perſon, ſo true, faithful, and ſure a friend. Thevenot introduced his gueſt to a great many other gentlemen, who met frequently at his houſe with a view of cultivating the arts and ſciences; but in all their aſſemblies our author continued for a long time, notwithſtanding all the company's entreaties, a ſilent auditor only, till his modeſty being at laſt overcome by repeated importunities, he found himſelf obliged to give one and then another ſpecimen of his manner of diſſecting inſects, and of ſhewing their inward parts; by which he gained great applauſe, as by his tacit ſkill he effectually ſilenced the talkative ignorance of others. Thevenot, moreover, ſtrenuouſly recommended our author's ſkill to that great man Conrad Van Beuningen, a ſenator and burgomaſter of Amſterdam, and at that time that republick's miniſter at the court of France; who obtained leave for Swammerdam at his return home, to diſſect the bodies of ſuch patients as ſhould happen to die in the hoſpital of that city: and our author improved himſelf greatly in anatomy, by making the proper uſe of ſo favourable an opportunity.

But this was not the only opportunity which providence threw in our author's way at this time, as the principal phyſicians of Amſterdam had formed a college, and had agreed to meet together every other week in order to confer on medical, but chiefly anatomical ſubjects, and to make experiments relative thereto. The obſervations of this ſociety of learned men were afterwards publiſhed by Caſper Commelin, in the year MDCLXVI and LXVII, before Swammerdam had been created doctor of phyſic; notwithſtanding which, he was the firſt to furniſh materials for it. It was he, and he alone, that made in the ſaid college, with his own hand, a drawing of the ſpinal marrow, publiſhed by Blaſius at the ſame place; and on this occaſion he wrote to Thevenot the following particulars. I. That the ſpinal marrow conſiſts entirely of fibres. II. That thoſe diſtinct fibres meet and terminate in ſome part of the brain. III. That there iſſue fibrous nerves from the fibres of the ſpinal marrow. IV. That the pia mater is altogether extended into hollow ſheaths. V. That all theſe things may be eaſily ſeen, by ſuddenly placing the yet warm ſpinal marrow along with the vertebræ containing it, in cold water, and breaking the vertebræ with great caution from the marrow, after having ſuffered both to remain in that ſituation during the ſpace of a day and a night. This letter was written the firſt of April MDCLXVI; our author at the ſame time tried many experiments by injecting the veſſels of living animals with various liquids. See de Reſp. page 103 and 107. He even made ſome chemical experiments on the cold fermentation produced by mixing together the ſalt of urine, and the ſpirit of glauber ſalts, ibid. p. 111. He then too compoſed that laborious eſſay on reſpiration, which he was to maintain on his declaiming for his degrees in phyſic. We may be convinced by reading this performance, that he only purſued ſuch things as he thought of in his own way, and of whoſe truth he had ſatisfied himſelf, and could convince others by experiments, without borrowing any aſſiſtance from other writers. Having finiſhed this diſſertation, he came back to Leyden to take out his degrees; and took occaſion of his ſtay there to cultivate a moſt intimate friendſhip with the famous Van Horne, who had been formerly his preceptor in the ſtudy of anatomy. With this gentleman he then practiſed this uſeful art, and prepared a great many things in many various ways, while both publickly owned a community of ſentiments and diſcoveries. The profeſſor moſt liberally ſupplied all kinds of materials, the other directed the work, and at the ſame time made with his own hands the moſt maſterly drawings of each diſcovery, which he immediately forwarded with ſuitable obſervations to Matthew Slade. Nothing here was wanting to carry on ſo laudable an undertaking. Van Horne's liberality contributed the ſubjects, the inſtruments, and every other expence; and Swammerdam's wonderful ſkill was day and night employed in making proper uſe of them. It was at this time, and on the twenty-ſecond of January MDCLXVII, that in Van Horne's own houſe, Swammerdam firſt injected the uterine veſſels of a human ſubject with a ceraceous matter, which moſt uſeful attempt he afterwards improved and perfected. The twenty-ſecond of February of the ſame year, he was admitted to his degrees as doctor of phyſic, after having publickly maintained his diatriba or theſis on reſpiration; which was then conceived but in ſhort and contracted arguments, but appeared the March following with conſiderable additions in a volume from the printing-houſe of Gaſbekios, with a dedication to the illuſtrious Thevenot, and adorned with a frontiſpiece of a moſt elegant figure of the reciprocal copulation of the hermaphrodite houſe Snail. John Baptiſt Van Lamſweerde publiſhed in oppoſition to this of Swammerdam another moſt vehement diſſertation, which he entitled, "An Exſpiration of Swammerdam's Syſtem of Reſpiration;" but this attempt fell ſhort of its author's expectation: for though Swammerdam's book may contain ſome things out of the way, they will be readily excuſed by equitable judges, in conſideration of the many curious and juſt obſervations that are to be met with in every part of that work. Another occupation of Swammerdam's at this time was to blow up with air the parts of the body firſt properly evacuated and cleanſed, that by drying in this ſituation they might afterwards retain it, and ſo at all times afford an opportunity of obſerving and deſcribing them. This certainly muſt be allowed one of the moſt uſeful inventions in anatomy, as by it we can erect and ſtiffen parts, which would putrefy on lying one upon another, and which if injected with wax would be rendered obſcure and confuſed. It was thus our author cultivated anatomy with the greateſt art and labour, in conjunction with the celebrated Van Horne; but a quartan ague, which attacked him this year, brought him ſo very low, that he found himſelf under a neceſſity of diſcontinuing his anatomical ſtudies, which on his recovery he entirely neglected, in order to give himſelf up to the ſtudy of inſects. In the year MDCLXVIII the great duke of Tuſcany being then in Holland with Mr. Thevenot, in order to ſee the curioſities of the country, came to view thoſe of our author and his father, and ſurveyed them with the greateſt delight, and his uſual taſte and attention for natural hiſtory. On this occaſion Swammerdam made ſome anatomical diſſections of inſects in the preſence of that great prince, who was both a lover and a moſt ſkilful judge of ſuch things, and who was ſtruck with admiration at our author's great ſkill in managing them, eſpecially at his proving that the future Butterfly lay with all its parts neatly folded up, in a Caterpillar, by actually removing the integuments that covered the former, and extricating and diſtinctly exhibiting all its parts, however minute, with incredible ingenuity, and by means of inſtruments of an unconceivable fineneſs. On this occaſion his ſerene highneſs offered our author twelve thouſand florins for his ſhare of the collection, on condition of his removing them himſelf into Tuſcany, and coming to live at the court of Florence. In this certainly the prince acted very wiſely, as thoſe curioſities would be in the greateſt danger of being loſt or becoming uſeleſs, if not preſerved and ſhewn by the great genius that had collected them, and who was alone capable of ſhewing every article, and exhibiting them to the greateſt advantage; but Swammerdam, who hated a court life above all things, rejected his highneſs's propoſal. Beſides, he could not put up with the leaſt reſtraint in religious matters, either in point of ſpeech or practice. In the mean time, he had the happineſs of diſcovering in the diſſection of an overgrown Acipenſer, a very large pancreas, which, by diſcharging its fluid contents into the firſt inteſtine through a great many ſpacious and open-mouthed channels, gave a moſt ſatisfactory opportunity of examining this, at that time, ſo famous and much-talked-of fluid, in which, on the ſtricteſt examination, he could diſcover no acid taſte, but rather a bitteriſh rankneſs, reſembling that of gaurus, or pickle made of fiſh.

This our author affirmed publickly, contrary to what had been before advanced by de Graaf and Sylvius. He alſo made ſome obſervations in the hoſpital, but merely as ſupplementary additions to his other inquiries; for he now made the nature and properties of inſects his chief ſtudy, and purſued it with infinite diligence, and without the leaſt relaxation; ſo that in the year MDCLXIX, he publiſhed a general hiſtory of them, a work equally remarkable for

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the author's great boldneſs in the attempt, and happy ſucceſs in the execution. This performance he dedicated to the honourable the burgomaſters of Amſterdam. But as he was entirely bent on perfecting this work, and collecting of inſects from every quarter of the world, and then diſpoſing them in ſeparate boxes in order to form a compleat catalogue, which was attended with great and conſtant expences, without the leaſt return. Our author's father, who had always kept him at home, and ſupplied all his expences, began to take offence at his proceedings; for though he was now above thirty years old, and conſequently had ſpent the beſt years of his life, he had not as yet engaged in any buſineſs that could ſerve to render him eaſy and independant. His father on this account omitted no opportunity of reproving his ſon for this his thoughtleſs way of acting, which he would have had him change for the practice of phyſic; but inſtead of prevailing on him by his remonſtrances, they only ſerved to make him redouble his endeavours according to his diſpoſition, that he might the ſooner finiſh the great taſk in which he had ſo couragiouſly, though perhaps unadviſedly, engaged; all the while ſtriving to divert his father's anger, by promiſing him, that as ſoon as he had completed his undertaking, he would in good earneſt apply himſelf to the practice of phyſic. But his father ſeeing no probability of his ſon's accompliſhing his purpoſe, nor yet of being able to divert him from it by fair means, threatened him ſeverely that if he did not immediately exert his talents as a phyſician, but obſtinately perſiſted in his anatomical ſtudies, his expenſive reſearches after inſects, and his experiments of that kind, he would neither ſupply him with money or cloaths; and to ſhew he was in earneſt, he immediately deprived him of the means of purſuing what he had begun. Our author therefore, though exhauſted with continual labours, and moreover afflicted with a continual bad ſtate of health, at laſt conſented to take his father's advice, the juſtneſs of which he now began to perceive; but his bad health rendered him quite unfit to bear the fatigues uſually attending the practice of phyſic, ſo that he thought it was proper that he ſhould retire into the country for ſome time, in order to recover his ſtrength, and with a view of returning to his buſineſs with new force and ſpirits. But he was ſcarce ſettled in his country retirement, when in the month of June MDCLXX, he relapſed into his former occupation, the torrent of his genius that way being ſo much favoured by the ſolitarineſs of the place, and the favourable opportunity of examining inſects in their very haunts and ſcenes of propagation. Thevenot, in the mean time, informed by his correſpondents in Holland of the diſagreement between our author and his father, and the bad conſequences that might probably attend it, did all that lay in his power to engage the former to retire into France, where he moſt generouſly offered to provide him with every thing requiſite for the purſuit of his favourite ſtudies. But whatever impreſſion this propoſal might have made on the ſon, the father forbid him to accept of it, as appears by a letter of his to Mr. Thevenot, dated the thirtieth of October of the ſame year. The ſon upon this, to oblige and appeaſe his incenſed father, made an accurate ſurvey of every curioſity in the latter's grand and numerous collection, put all things in their proper places, and compoſed a moſt exact catalogue of them with infinite pains and labour, and a conſiderable loſs of time, which he ever after ſeverely regretted. The year following, MDCLXXI, having gone through this tedious and diſagreeable taſk, he was about publiſhing his treatiſe on the Chameleon and Hemorobion, or Day-Fly; but afterwards thought proper to defer the publication of thoſe pieces, ſo that they did not appear till the year LXXV, though he had formerly printed ſome part of them in Ruylenburgh, and even in France, ſo early as the year MDCLXVII.

On the firſt of May LXXII he ſent to the Royal Society of London three plates and ſix figures, in which he had repreſented the womb of a human ſubject, dedicating them at the ſame time to that learned body. To them he added ſome moſt curious drawings of the ſpermatic veſſels, the tube of the womb, and the ovary. All theſe curious pieces had been ſketched out in profeſſor Van Horne's houſe by the twenty-firſt of January, MDCLXVII, though not finiſhed or illuſtrated with proper explanations till the ſeventh of May MDCLXXI. Thus for the firſt time was publiſhed a ſpecimen of a method, by which both arteries and veins, and their fineſt ramifications, can be filled with a ceraceous matter, which not only renders thoſe parts perfectly viſible, but even incorruptible: and our author, to procure due credit to his drawing, ſent with them the uterus itſelf prepared according to this his new method. His motive in all this proceeding, was to have the opinion of learned and equitable judges of ſuch kind of performances. Another thing he had in view, was to convince the world that it was indebted to him as the firſt inventor, for the diſcoveries relating to the ſpermatic veſſels, which the celebrated Van Horne had before publiſhed in his Prodromus. But above all things, he by this means endeavoured to refute what Regnier de Graaf had written againſt him, with the greateſt bitterneſs, concerning ſome diſcoveries in regard to the organs of generation; and for this purpoſe he appealed to the judgment of the members of the Royal Society, to whom, as far as it concerned him, he gave full power and authority to decide the controverſy.

About this time he made a great many other very uſeful anatomical diſcoveries: in particular he diſſected a great number of fiſhes, with a view chiefly of diſcovering their liver, pancreas and melt; and in the courſe of his inquiries very often found in ſome a very large pancreas, with a great number of ſpacious and wide-mouthed ducts opening into the inteſtines: but above all things he applied himſelf with the greateſt diligence to find out by every trial that promiſed any ſucceſs, the true nature and properties of the pancreatic fluid, of which he ſent many bottles full to the celebrated Charles Drelincourt, then profeſſor of anatomy and phyſic in the univerſity of Leyden. All theſe particulars may be ſeen in the ſecond part of the Private College of Amſterdam, publiſhed by C. Commelin in the year MDCLXXIII; for there is ſcarce any thing in all that performance, for which the world is not indebted to our author; who there very mildly and modeſtly refutes de Graaf and Sylvius's accounts of the pancreatic fluid, though he formerly uſed to treat with great harſhneſs thoſe who contradicted his ſentiments, as appears in the literary controverſies he before this had maintained with de Graaf, Gaſper, Bartholin, and others. But religion and piety had by this time got the better of our author's warm and ſtubborn temper. Happening to read ſome books which the then famous Antonia Bourignon had a little before publiſhed, they made ſo great an impreſſion upon him, that a ſtrict compliance with all the duties of a good chriſtian was now become his principal concern. He began to hate and ſhun all thoſe things which men moſt covet and run after, but bent his endeavours more particularly to ſuppreſs the unruly paſſions of the mind, and above all that inſatiable ambition which makes us ſo deſirous of a ſuperiority over others, and which therefore, as the root of all evil, he was deſirous utterly to extirpate and deſtroy. All this time Antonia Bourignon happened to be in Holſtein, accompanied by John Tielens, a native of Amſterdam, with whom Swammerdam had been long acquainted. He therefore writ to his friend the eighteenth of March MDCLXXIII, to beg he might procure him Antonia's good will, and leave to write to her on his ſpiritual concerns; and having obtained this favour, he accordingly writ to her the twenty-ninth of April following, and received an anſwer to his letter dated the ſeventeenth of Auguſt. Her advice wrought ſo great a change in him, that at that time he thought of nothing but of obtaining from God a holy peace of mind, ſincerely grieving that he had loſt ſo much time in the ſervice of the world. After this he writ many more letters to Antonia, who very graciouſly anſwered them. About this time he was, if I am not miſtaken, the firſt that diſcovered a thing of very great importance, for he found that the hernia in both men and women never proceeds from a rupture of the peritoneum, but that the peritoneum alone is extended over the part where the ſeminal veſſels, encloſed in one caſe or ſheath, but which before this lay cloſe under the peritoneum, fall from it towards the ſcrotum. Now, if in this caſe the peritoneum happens to inſinuate itſelf into that wide paſſage, by which the ſpermatic cord falls down towards the teſtes, it there, whatever cauſe may preſs it, forms a ſacculus cæcus, or blind bag, on account of its wonderful extenſibility, and the ſmoothneſs of the cavity made for it by the deſcent of the ſpermatic cord. The ecphyſis once formed, grows larger and larger, as the cauſe which firſt produced it increaſes; and continuing to keep cloſe to the ſpermatic cord, follows it towards the ſcrotum, above the os pubis, and along the outſide of the muſcles. If this ecphyſis ſtops at the groin, it forms what is called a bubonoceles; but if it deſcends to the ſcrotum, an oſcheoceles; beſides which, it obtains a variety of other names, from the different ſubſtances that may happen to fall into it, ſuch as the omentum, the inteſtine, air or water. The ſame is the caſe in women, except that the deſcent is made along the femoral veſſels, (See Schraderi, Obſerv. Decad. II. Obſerv. IV. V.) where there is a very exact drawing to repreſent the nature of this diſorder. Many eminent perſons have ſince made pretenſions to the honour of this diſcovery, but the account I have given of it appears the moſt probable. In this book too there is another obſervation of our author equally important; for he there mentions his having ſeen two cicatrices in the ovary of a woman, that had been brought to bed of twins; which it is duely to be remarked happened at the ſame time. In the ſame collection there is our author's contrivance for preſerving the parts, or anatomical preparations in balſam. For all theſe reaſons, the editor thought proper to dedicate this work, publiſhed in MDCLXXIV, to Swammerdam, who was the chief contributor to it. Our author, moreover, in the year MDCLXXIII, had exhibited to the illuſtrious Arnold Syen, profeſſor of botany in the univerſity of Leyden, the ſeminal little bags of Fern, and the delineations he had made of them. I intreat the reader to view and conſider attentively the deſcriptions and figures contained in this book, and compare them with thoſe given a long time after by ſome of the greateſt botaniſts. There cannot be a greater reſemblance between two eggs, than there is between our author's performance this way, and thoſe that followed. The ſame things might have been ſeen in France, nor is it impoſſible that they might have been deſcribed there too. The laſt day of September of this year, our author finiſhed his treatiſe on Bees, which proved ſo fatiguing a performance, that he never after recovered even the appearance of his former health and vigour: and indeed it was an undertaking too great for the ſtrongeſt conſtitution, to be continually employed by day in making obſervations, and almoſt as conſtantly engaged by night in recording them by drawings, and ſuitable explanations. This being ſummer work, his daily labour began at ſix in the morning, when the ſun afforded him light enough to ſurvey ſuch minute objects; and from that hour till twelve he continued without interruption, all the while expoſed in the open air to the ſcorching heat of the ſun, bearheaded, for fear of interrupting the ſight, and his head in a manner diſſolving into ſweat under the irreſiſtable ardors of that powerful luminary. And if he deſiſted at noon, it was only becauſe the ſtrength of his eyes was too much weakened, by the extraordinary afflux of light and the uſe of microſcopes, to continue any longer upon ſuch ſmall objects, though as diſcernible in the poſtmeridian, as they had before been in the antemeridian hours.

This fatigue our author ſubmitted to for a whole month together, without any interruption, merely to examine, deſcribe, and repreſent the inteſtines of Bees, beſides many months more beſtowed upon the other parts; during which time he ſpent whole days in making obſervations, as long as there was ſufficient light to make any; and whole nights in regiſtering his obſervations, till at at laſt he brought his treatiſe of Bees to the wiſhed-for perfection: a work which all the ages from the commencement of natural hiſtory to our own times, have produced nothing to equal, nothing to compare with it. Read and conſider it, and then judge for yourſelf. Our author, the better to accompliſh his vaſt unlimited views, often wiſhed for a year of perpetual heat and light to perfect his inquiries, with a polar night to reap all the advantages of them by proper drawings and deſcriptions. In his eſſay on the Hemorobion, or Day Fly, he ingenuouſly owns that this his treatiſe of Bees was formed amidſt a thouſand torments and agonies of heart and mind, and ſelf-reproaches, natural to a mind full of devotion and piety. On one hand his genius urged him to examine the miracles of the great Creator in his natural productions, whilſt on the other, the love of that ſame all-perfect Being deeply rooted in his heart, ſtruggled hard to perſuade him, that God alone, and not his creatures, was worthy of his reſearches, love and attention. The diſtreſs of mind our author felt upon this occaſion, was ſo ſevere that as ſoon as he had finiſhed his book upon Bees, he put it into the hands of another, without knowing or giving himſelf the leaſt concern about what might become of it. It appears however, that he at the ſame time wrote two letters to Paul Boccone, on the conſtruction of ſalt water or ſea ſtones and corals, which are to be found in the nineteenth and twentieth letters of the ſaid Boccone's natural obſervations. After this Swammerdam grew almoſt altogether careleſs of the arts he had been hitherto fondeſt of. He had conceived this diſtaſte for wordly affairs above two years before, though he had ſtruggled againſt it in favour of his book on Bees; but now he could no longer allow his mind any other occupation beſides that of loving and adoring the Sovereign Good, to whoſe honour alone he openly declared, he began and directed his many and great labours in the cultivation of natural hiſtory, from which he now entirely deſiſted merely to devote all the little uncertain portion of life that remained, to the ſincere practice of every chriſtian virtue. His temperament was of the melancholy kind, which phyſicians have obſerved to be very firm in its purpoſes, and our author's natural diſpoſition was encreaſed by a quartan ague, ſo that he preſevered in his reſolution, in which the authority and advice of Antonia Bourignon fixed him beyond a poſſibility of relapſing into his former worldly way of thinking. He therefore reſolved to withdraw himſelf entirely from all converſation with the world, but had firſt the prudence ſeriouſly to examine, what would be neceſſary to maintain him in his retirement. This he found to amount yearly to four hundred Dutch florins or gilders, without having any thing but his curioſities to raiſe ſuch an income by. Theſe therefore he immediately reſolved to ſell, in hopes the produce of them put out to intereſt, would be ſufficient to anſwer his demands. The firſt he applied to on this occaſion, and the only perſon perhaps who knew any thing of our author's private intentions, was Thevenot, whom he requſted to publiſh and forward the ſale of thoſe things, which he had ſpent ſo much time and labour in collecting, and formerly ſo much loved. Thevenot did all that lay in his power to ſerve his friend, but to no purpoſe; for however valuable the treaſure, no one was to be found in France willing to purchaſe it, though our author was often flattered with the hopes of its ſelling to advantage. This diſappointment made Swammerdam apply to another friend. This was Nicholas Steno, who having renounced the religion of his country, was become a member of the church of Rome, had obtained a biſhopric as a reward for his change, and to induce him to continue in it, and now lived at the court of Florence. Swammerdam wrote to him to know if the grand duke was now as willing, as he had formerly been, to purchaſe his curioſities. In anſwer to this letter, the new convert's zeal made him uſe every argument he could think of to make our author, after his own example, conform to the church of Rome, and remove with his collection into Tuſcany, promiſing him for certain, that the great duke would let him have for his curioſities the price of twelve thouſand florins, which his highneſs had formerly offered, and let him want for nothing, that could make life eaſy and agreeable. But our author looked upon theſe conditional offers as the greateſt indignity that could be offered him, and accordingly bitterly reproached his friend Steno for endeavouring to prevail upon him in a manner he utterly deteſted, telling him withal that his ſoul was not venal; and Bourignon being conſulted on the occaſion, adviſed him by all means to reject Steno's propoſals. Our author agitated by ſuch a ſeries of hopes and diſappointments, made uſe of the little leiſure that remained on his hands, in arranging and adorning his curioſities; rendering them as durable as poſſible, and compoſing a complete catalogue of them, ſo that in his muſeum thus ſettled, the materials and the contrivance, the dignity of the ſubjects, and the vaſt pains taken in procuring, preparing, and exhibiting them, vied together for the preference. Theſe treaſures conſiſted chiefly of inſects and anatomical preparations from human ſubjects. The former our author ſet the higheſt value upon, and no wonder, as he had ſpent ſixteen years in collecting and preparing them, with infinite pains and expence. The ſight of his muſeum was alone ſufficient to prove, that what all former authors had publiſhed on this branch of natural hiſtory, amounted to nothing more than a dry catalogue of names, and ſome external figures, without affording any certain and uſeful knowledge. Whereas our author alone had collected near three thouſand ſpecies of inſects, that had no relation one to the other, and had examined every one of them, and diſpoſed them all in claſſes according to their real and natural characters; he had even diſſected many of them with that ſkill and dexterity peculiar to himſelf, and having with unwearied diligence traced them through every the leaſt period of their changes from the egg to the Butterfly, faithfully recording all his obſervations, taking care at the ſame to prepare and keep by him the minute originals as inconteſtable vouchers of his indefatigable induſtry in examining them, and his ſcrupulous veracity, relating what he had diſcovered. Nay, that nothing ſhould be wanting to perfect his diſcoveries, he uſed himſelf to hatch, in a manner found out by, and only known to himſelf, the little eggs of inſects, in order to diſcover the obſcure manner of the exiſtence of their firſt rudiments, the progreſs of theſe rudiments to life, the firſt motions of the infant animalcula, and by what endeavours they at laſt broke their eggs, and opened themſelves a paſſage into the world. While thus employed, he at length publiſhed at Amſterdam the twelfth day of July MDCLXXV, his hiſtory of the Ephemerus, or Day-Fly; which he began in France in the year LXIV, continued in Guelderland in the year LXVII, but did not perfect till this time, that he made it public. However even this, he did not attempt without Bourignon's approbation. This was the laſt offspring of our author's great genius and application, after which he entirely renounced all thoughts of human affairs, to think of nothing but his ſpiritual concerns, which he imagined he could not ſo well promote in any other manner, as by going to confer perſonally with Bourignon. Accordingly, having firſt obtained her leave for that purpoſe, he ſet out the autumn following from Amſterdam for Sleſwick in Holſtein, where ſhe then reſided, arrived there the thirtieth of September, and ſpent ſome time in her houſe. Mean while the Lutheran divines of that country, utterly averſe to Bourignon's undertakings, were for making her quit Holſtein, which made her think of aſking the king of Denmark's leave to take ſhelter in his regal dominions. Swammerdam having taken upon him to execute this commiſſion, ſet out for Copenhagen, in company with another of her diſciples, the twenty-fifth of March, MDCLXXVI. Here he ſaw Steno's mother, now far advanced in years, but reaped no other benefit by his journey, his Daniſh majeſty not thinking proper to grant Bourignon's requeſt. After this our author made but a ſhort ſtay at Sleſwick, from whence he ſet out for Amſterdam the ſixteenth of June following. On his coming home, he had the mortification of finding that his father's diſpleaſure at his paſt conduct, inſtead of being appeaſed, was grown more violent on account of his late undertakings. Another and greater ſubject of affliction was, the marriage of his ſiſter Joanna, who had hitherto kept houſe for her father ſince he had buried his wife; for the father on this occaſion had reſolved to break up houſe-keeping, and to live for the future with his ſon-in-law, Our author therefore now found himſelf under the ſad neceſſity of ſhifting for himſelf by the month of May following. How great, alas! muſt have been his diſtreſs! He had neither money nor any thing of value except his muſeum, which he had already ſo often endeavoured in vain to diſpoſe of; and his father did not propoſe to allow him more than two hundred florins a year. On this occaſion he formed a deſign of retiring into the country, and flattered himſelf with the hopes of being able to provide for himſelf that way. The moſt noble John Ort of Nieuwenrode Breukele, &c. had contracted a friendſhip of a very long ſtanding with our author, and had often entertained him at his pleaſant country ſeat with the greateſt hoſpitality and politeneſs, and even invited him to remain there for good and all, and purſue his ſtudies without interruption. But Swammerdam never till now found himſelf under a neceſſity of putting his friend's ſincerity to the teſt; however he little expected the refuſal he now met with, and which, as it convinced him of the little dependance to be had on the promiſes of men, greatly contributed to increaſe his former anxiety. But his father dying this year put an end to his troubles, by leaving him a ſufficiency to live, in a manner ſuitable to his own inclinations, for now he ſaw himſelf freed from all buſineſs, but that of ſerving God, which alone he delighted in. But his joy was ſoon interrupted, when the father's fortune came to be divided, and his muſeum to be diſpoſed of, the ſiſter claiming more of the inheritance than came to her ſhare, and the chief direction of the ſale, while Swammerdam for the ſake of peace and quietneſs, and in order to get the ſooner into his long wiſhed for retirement, ſubmitted to her unjuſt pretentions. Nevertheleſs, the vexation attending this family ſtrife, joined to the uninterrupted fervour of his devotion, brought a tedious diſorder upon him. This was a double tertian ague, which afterwards continued without intermiſſion, and then changed in different manners. Whilſt this fit of ſickneſs continued, he got up but ſeldom in the day time, and for three months together that the ſlow fever continued, he never went out of his houſe; he was even a whole twelve month without making a ſingle experiment. At laſt his diſorder, again changing to a tertian ague, ſeemed to abate, and then entirely left him for ſome days. His friends nevertheleſs, and among them doctor Matthew Slade, a moſt learned phyſician, and one whoſe advice had the greateſt weight with our author, could never prevail upon him to ſtir from his bed-chamber. He would often excuſe himſelf by ſaying that ſolitude and retirement could alone extirpate the relicks of his diſorder; when Slade, Ruyſh, Schrader, Hotton and Guenellon, who all of them frequently viſited him in the quality both of friends and phyſicians, attempted to perſuade him to the uſe of medicines and freſh air for the recovery of his former ſtrength and vigour. But he at laſt put a ſtop to their importunities by an obſtinate ſilence. However as the things he formerly took moſt delight in, were now become odious to him, and he had no further hopes of being able to diſpoſe of them in France, he wrote to his friend Thevenot, who had again invited him to his houſe, that he would accept of his kind offer, provided he would immediately diſpoſe of his curioſities for him, and permit him to live quite unknown and retired. But here too our author was again diſappointed, ſo that at laſt he advertiſed a fixed day in the month of May following, MDCLXXX, for the ſale of his curioſities, article by article, to the beſt bidder; ſo great a deſire he had of getting rid of them, notwithſtanding that he had ſeen that his father's muſeum, when ſold in ſingle lots, had not produced above a ſixth part of what his executors expected it would have ſold for. But whilſt our author was taken up in this manner, his old diſorder broke out anew with worſe ſymptoms than had hitherto appeared, an emaciated countenance, hollow eyes, a ſlow continued fever which eating always increaſed, and a ſwelling in his feet, legs, thighs and belly, attended with conſtant and uninterrupted pains. All this time his friends durſt not make the leaſt mention before him of his former ſtudies, nor did he himſelf ever ſpeak a word of them; for he now utterly deteſted as vain and inſignificant the things he formerly moſt delighted in. Thevenot, informed of the languiſhing condition he was in, offered him the jeſuit's bark, then greatly talked of for its efficacy in curing fevers, and Swammerdam deſired he might ſend him ſome of it, and ſome ſpecific againſt the dropſy, if he knew of any. But at laſt finding himſelf grow worſe and worſe, he made his will the twenty-fifth of January MDCLXXX, and left Melchiſedeck Thevenot, formerly the French king's miniſter at Genoa, all his original manuſcripts belonging to the natural and anatomical hiſtory of Bees and Butterflies, with fifty-two plates belonging to them, and ordered all thoſe valuable papers then laid up in the houſe of Herman Wingendorp at Leyden, to be delivered to the legatee within a year after his death; but earneſtly recommended that his treatiſe on

Bees ſhould be publiſhed in Dutch as well as Latin, as diſplaying the wiſdom and power of God in ſo particular a manner. The little portion of life, that he enjoyed after this diſpoſal of his worldly concerns, he gave entirely to his ſpiritual ones, ſpending his whole time in acts of love and adoration of the Supreme Being, and thus ended his courſe the ſeventeenth of February following. He conſtituted Magaret Volckers, wife of Daniel de Hoeſt, doctor of phyſic, his heireſs, and her and Chriſtopher Van Wyland his executors, but Van Wyland dying ſoon after, the truſt devolved wholly into the hands of Madam Volckers.

As ſoon as our author's executors had performed the laſt rites due to their deceaſed friend, Mr. Ort at their requeſt gave Mr. Thevenot notice of the legacy left him in Wingendorp's hands; for Swammerdam being little verſed in the Latin, in which notwithſtanding he was deſirous of ſeeing all his works publiſhed, had given them to Wingendorp to tranſlate into that language, as he had before done our author's writings on the uterus. Thevenot on this wrote ſeveral times to doctor de Hoeſt, to deſire he ſhould immediately cauſe his legacy to be delivered him; but Wingendorp, who was poor, and lived by his tranſlations into various languages, after endeavouring by a thouſand frivolous pretexts to make a property of what he had only been entruſted with, at laſt openly declared he would return nothing till compelled to it by due courſe of law. Upon this therefore a tedious and troubleſome lawſuit enſued, in which however Thevenot at laſt obtained a decree in his favour in May MDCLXXXII, when Swammerdam's papers in the hands of Wingendorp were delivered to Burcher de Volder, a celebrated profeſſor of anatomy and mathematics, whom Thevenot had engaged as a friend to take his intereſt in hand, and without whoſe diligence and prudent management, it is poſſible that Thevenot would have loſt his legacy. As ſoon as Thevenot heard of his friend's ſucceſs, he gave orders to have the writings in queſtion publiſhed in Dutch, but ſoon altered his opinion, and ſent for them. He then attempted ſome alterations in them, as I could diſcover by the eraſements made here and there with his own hand; but in this he fell ſhort of anſwering Swammerdam's intentions, though probably only for want of abilities ſuitable to ſuch a taſk. Be that as it will, this valuable treaſure, after Thevenot's death, was purchaſed by Joubert the king's painter, whoſe heirs afterwards ſold it at the inconſiderable price of fifty French crowns to the illuſtrious Joſeph du Verney, with whom they lay hid and diſregarded for a long time. At laſt a report prevailing that the anatomy of inſects was coming into great vogue, and that a hiſtory of this part of the creation, compoſed by the great anatomiſt juſt now ſpoken of, was upon the point of appearing at Paris, I requeſted William Sherard my gueſt at that time, and moſt intimate friend, to obtain ſome certainty for me in regard to this report, as he was then about making a journey into France. Accordingly on his arrival at Paris, he wrote that Swammerdam's works were in the hands of Monſieur du Verney, and even ſent me ſome copperplates after the drawings of our author, which when I examined, ſerved only to excite my ambition of aſſerting the right of my country to the honour of having produced the originals, and making without loſs of time all the inquiries I judged neceſſary for that important end. At laſt, by the aſſiſtance of the reverend Mark Guitton, and the eminent William Roell, profeſſor of anatomy at Amſterdam, both then reſiding in Paris, I ſo far ſucceeded, that they were purchaſed for me the twenty-ſixth of

March,

March, MDCCXXVII, at the price of one thouſand five hundred French florins, and I received them complete the ſame ſummer. As ſoon as I had got them, I read them; and having diligently examined them more than once, I carefully digeſted them, and had the ſatisfaction of ſeeing that nothing was wanting except a few pages of the text in the treatiſe of Bees, which a note in the margin obſerved was not to be repaired; however, on looking narrowly for them, I had the good fortune of finding them elſewhere. Upon this, I ſhould have publiſhed them directly, but for the inſatiable avarice, and unbounded audaciouſneſs of the printers, who make nothing of reprinting things as ſoon as they appear, to the great loſs of the firſt publiſhers. However, I have at laſt ſucceded in guarding againſt ſuch foul treatment, and return my hearty thanks to all thoſe who ſo generouſly contributed their aſſiſtance on this occaſion. And now I muſt own, that it is with the greateſt pleaſure I find myſelf enabled by this valuable work to challenge all thoſe nations, who ſo liberally reproach us Dutchmen with a dullneſs that requires the inventions of others to ſharpen it, to produce before able judges, any thing equal to this performance of one of our countrymen. This inſtance will, I believe, be ſufficient to convince mankind that we have among us uncommon geniuſes, who have made the moſt important diſcoveries, and ſpider-like, have furniſhed themſelves alone both the workmanſhip and materials. However I muſt in juſtice own, there is now in France ſuch another bright ſun, who by his light not only ſhews, but adds grace and dignity to every object he is pleaſed to ſhine upon. I mean that prodigy of our age, and glory of his country, the illuſtrious Reaumur. God grant this great man life to go through, and many years to ſurvive, his great undertaking.

I examined with the greateſt care and attention all the letters, and other writings of Swammerdam, that I could lay my hands on, in order to find out the methods taken by him to perfect thoſe beautiful diſcoveries, by which he has ſo far exceeded all authors in the ſame way; and I ſhall here candidly relate the fruits of my perquiſition. For diſſecting of very minute ſubjects, he had a braſs table made on purpoſe by that ingenious artiſt Samuel Muſſchenbroek. To this table were faſtened two braſs arms, moveable at pleaſure to any part of it, and the upper portions of theſe arms were likewiſe ſo contrived as to be ſuſceptible of a very ſlow vertical motion, by which means the operator could readily alter their heigth as he ſaw moſt convenient to his purpoſe. The office of one of theſe arms was to hold the little corpuſcle, and that of the other to apply the microſcope. His microſcopes were of various ſizes and curvatures; his microſcopical glaſſes being of various diameters and focuſes, and from the leaſt to the greateſt, the beſt that could be procured, in regard to the exactneſs of the workmanſhip, and the tranſparency of the ſubſtance. His way was to begin his ſurveys with the ſmalleſt magnifiers, and from thence proceed by degrees to the greateſt; and by nature and uſe was ſo incomparably dexterous in the management of theſe uſeful inſtruments, that he made every obſervation ſubſervient to the next, and all tend to confirm each other, and complete the deſcription. Theſe no doubt were talents very uncommon, though no leſs requiſite in an obſerver of ſuch things. But the conſtructing of very fine ſciſſors, and giving them an extreme ſharpneſs, ſeems to have been his chief ſecret. Theſe he made uſe of to cut very minute objects, becauſe they diſſected them equably; whereas knives and lancets, let them be ever ſo fine and ſharp, are apt to diſorder delicate ſubſtances, as in going through them they generally draw after them, and diſplace, ſome of the filaments: his knives, lancets, and ſtyles were ſo very fine, that he could not ſee to ſharpen them without the aſſiſtance of the microſcope; but with them he could diſſect the inteſtines of Bees with the ſame accuracy and diſtinctneſs, that others do thoſe of large animals. He was particularly dextrous in the management of ſmall tubes of glaſs no thicker than a briſtle, drawn to a very fine point at one end, but thicker at the other. Theſe he made uſe of whenever he had a mind to ſhew, and blow up the ſmalleſt veſſels diſcovered by the microſcope; to trace, diſtinguiſh, and ſeparate their courſes and communications, or to inject them with very ſubtil coloured liquors. As to the inſects themſelves, he uſed to ſuffocate them in alcohol or ſpirit of wine, in water, or ſpirit of turpentine, and likewiſe preſerved them for ſome time in theſe liquids, by which means he kept the parts from putrefying, and conſequently collapſing and mixing together; and added to them, beſides, ſuch ſtrength and firmneſs, as could not fail of making the diſſections far more eaſy and agreeable. When he had divided tranſverſely with his fine ſciſſors the little creature he intended to examine, and had carefully noted every thing that appeared without further diſſection, he proceeded to extract the viſcera in a very cautious leiſurely manner, with other inſtruments of equal ſubtility; but firſt took care to waſh away and ſeparate with very fine pencils the fat with which inſects are moſt plentifully ſupplied, and which always occaſions ſome damage to the internal parts, before they can be extracted. This laſt operation is beſt performed upon inſects whilſt in the Nymph ſtate. Sometimes he put into water the delicate viſcera of the inſects he had ſuffocated, and then ſhaking them gently, procured himſelf an opportunity of examining them, eſpecially the air veſſels, which by this means he could ſeparate from all the other parts whole and entire, to the great admiration of all thoſe who beheld them; as theſe veſſels are not to be diſtinctly ſeen in any other manner, or indeed ſeen at all without damaging them. He often made uſe of water injected by a ſyringe, to cleanſe thoroughly the internal parts of his inſects, then blew them up with air and dried them; by which means he rendered them durable, and fit for examination, at a proper opportunity. Sometimes he has examined with the greateſt ſucceſs, and made the moſt important diſcoveries in inſects that he had preſerved in balſam, and kept for years together in that condition. Again, he has frequently made punctures with a fine needle in other inſects, and after ſqueezing out all their moiſture through the holes made in this manner, filled them with air by means of very ſlender glaſs tubes, then dried them in the ſhade, and laſt of all anointed them with oil of ſpike, in which a little reſin had been diſſolved, by which means they retain their proper forms for a very long time. He had ſo ſingular a ſecret for preſerving the very nerves of inſects, that they uſed to continue as limber and as perſpicuous as ever they had been. As to Worms in particular, his way was to make a ſmall puncture or inciſion in them towards the tail, and after having very gently, and with great patience ſqueezed out all their humours, and great part of their viſcera, inject them with wax, ſo as to give and continue to them all the appearances of living, healthy, and vigorous creatures. He diſcovered that the fat of all inſects was perfectly diſſolvible in oil of turpentine, and that they could not be preſerved in balſam: and this diſcovery he always made the greateſt ſecret of, becauſe the fat of inſects when melted, and then dried, looks like lime ſcattered over the parts, ſo as to obſcure the viſcera, and make it utterly impoſſible to examine them; but then, however confuſed and immerſed they might have been before, they ſhew themſelves after this proceſs very plainly and diſtinctly, on being long and thoroughly waſhed with fair water. Very often he ſpent whole days in cleanſing of its fat in this manner, the body of a ſingle Caterpillar, in order to diſcover the true conſtruction of that inſect's heart. His ſingular ſagacity in ſtripping off the ſkin of Caterpillars that were upon the point of ſpinning their neſts, deſerves particular notice. This he effected by letting them drop by their threads into ſcalding water, and ſuddenly withdrawing them, for by this means the epidermis peeled off very eaſily; and when this was done, he put them into diſtilled vinegar and ſpirit of wine mixed together in equal portions, which, by giving firmneſs to the parts, gave an opportunity of ſeparating them with very little trouble from the exuviæ or ſkins, without any damage to the viſcera, ſo that by this contrivance the Nymph could be ſhewn wrapped up in the Caterpillar, and the Butterfly in the Nymph. All theſe wonders he performed by the light of the brighteſt mid-day ſun, and had brought his arts to ſuch perfection, that he could exhibit whenever he thought proper, the manner in which inſects were encloſed in inſects, and were to be extricated from their encloſures. He could at laſt change the Caterpillar to a Chryſalis at his pleaſure, and alſo could as he pleaſed forward, ſtop, and regulate its motions. He affirmed nothing but what he ſaw, and was able to demonſtrate every thing he affirmed. He in good earneſt followed Lord Bacon's advice; for his opinions were the fruit of his experience, and he could effect the very things, whoſe exiſtence he maintained. Obſervations alone, made with the moſt wonderful patience by experienced ſenſes, aſſiſted with the fitteſt inſtruments, led him into the method followed by nature in all her operations; and he ſo ſcrupulouſly adhered to that great guide, that whenever he formed a rule from particular obſervations, he did it with ſo much caution, as to let it include thoſe particulars only, from which he had deduced it, and extracted his canon. In explaining the works of nature, he uſed to reaſon by comparing his obſervations with one another, and never admitted the uſe of a general application of them upon any other occaſion. Thus he began, carried forward, and perfected without any aſſiſtance, in a private and middling ſtation of life, more diſcoveries than all the writers of all the preceding ages. By theſe means he found there were little creatures that breathe at the tail, and others that govern themſelves in the water by the help of a little bubble of air, which they expand at pleaſure to aſcend to the ſurface, and compreſs in like manner, when deſirous to ſink to the bottom; and can regulate it in ſuch a certain manner, that they can ſuſpend themſelves in any part of the water they chooſe. Some again he diſcovered, who have their legs fixed to their jaws; and others in which the penis of the male receives in copulation the vulva of the female, and a few which are of both ſexes at once, and act reciprocally upon each other as ſuch at one and the ſame time. In fine, from ſuch an infinite number of new and uncommon obſervations, he formed a ſyſtem ſuperior by many degrees to any thing of the kind that had as yet appeared. He even collected the materials upon which this ſyſtem was founded, rendered them durable, and digeſted them, in order to have always at hand undeniable vouchers for the truth of every thing he advanced. Such a fabrick had never been raiſed before, yet it was raiſed by him in ſo maſterly a manner, that it might have ſtood ages. But, O hard fate of induſtry! after having been driven himſelf to offer his curioſities to ſale more like a beggar that had nothing to give, than like a man who offered infinitely more than he aſked, and this too without ſucceſs; his heirs, after his deceaſe, made propoſals of ſelling them all, his anatomical preparations, his inſects, and his inſtruments, for the trifling ſum of five thouſand florins, without finding any one intelligent enough to buy them for his own uſe, or generous enough to purchaſe them for that of the public. Alas, what a loſs was this, never to be repaired! Theſe wonders of art and nature, by being ſeparated and ſcattered into different hands, loſt all their value, to the irretrievable diſhonour of an age, the moſt remarkable of any that had as yet ever been for ſtudies of this nature. As for you, my readers, I muſt inform you of the obligations you owe, on the preſent occaſion, to the great Gaubius, who from his ſincere love to the republic of letters, tranſlated all the works I now preſent you, from the original Dutch into Latin, that the curious of all nations might have the better chance of reading them; and perhaps it would have been a hard matter, if not impoſſible, to find another tranſlator equal to the taſk. The facts I have here related are collected from the hiſtory of the times, from a repeated peruſal of Swammerdam's works, and from the letters written or received by him. An accurate and well-digeſted collection of all theſe papers ſupplied me with materials for writing his life, and I intend to depoſit them all, as well as the original drawings made by his own hand in the moſt elegant and maſterly manner, in the public library of the univerſity, there to remain as an eternal monument of our author's merit, and of my exactneſs and integrity in writing his life, and publiſhing his labours; and, in fine, that ſuch as take delight in things of this kind, may by this means have an eaſy opportunity of ſatisfying their curioſity. It was thus I acted in regard to the poſthumous works of the celebrated Vaillant. Farewel reader.

LEYDEN, $17\frac{11}{9}35$.

HERMAN BOERHAAVE.

THE

AUTHOR's PREFACE.

CURIOUS reader, before I proceed to lay my obſervations before you, I muſt moſt humbly requeſt, that you will not be diſpleaſed, if in all this work I have only made uſe of my own obſervations, as a ſolid and immoveable foundation to build upon, and that from them I have deduced certain concluſions, ſolid theorems, and claſſes digeſted in due order. For as long as neither nature herſelf exhibits any thing in oppoſition to theſe theorems, nor other writers produce experiments to contradict them; we may reſt aſſured of the truth of what I have delivered; but then we muſt not wander beyond the limits of ſuch obſervations, nor by ſtraining them too much, make them extend to things not as yet ſufficiently diſcovered. Otherwiſe, as nature is utterly inexhauſtible, we ſhould be in danger of falling into errors; and indeed it is generally our own fault that things of themſelves ſufficiently clear and evident, become obſcure, and even impenetrable to us. Thus a perſon would be guilty of a great miſtake, who, after running over all the animals he knew, never to be at once male and female, ſhould from thence conclude, that both ſexes are never found in one and the ſame ſubject; whereas the contrary appears in Snails, which are all capable of impregnating as males, and conceiving as females, but with this reſtriction, that the ſame Snail cannot act upon itſelf; ſo that a mutual intercourſe of two is requiſite to carry on the buſineſs of propagation, as I many years ago demonſtrated before a numerous company. As therefore all the experiments I have hitherto made, agree perfectly together, and mutually ſupport each other, there is the leſs reaſon, till ſomething appears in the nature of things to break the thread of my ſyſtem, to be ſtartled at the objections of others, who never made the ſame obſervations, and are not perhaps properly qualified to make the ſame experiments. But if hereafter any thing ſhould occur, that I may have reaſon to think deſerves to be added to what I have already advanced, or exceeds the bounds to which I have confined myſelf, or appears repugnant to my former obſervations; I promiſe faithfully to publiſh them, though they ſhould abſolutely deſtroy the principles I have laid down, provided that they ſerve to confirm and illuſtrate the truth. And I moreover earneſtly requeſt all thoſe who love truth as I do, and are equally anxious to find it out, to aſſiſt me on this occaſion with their favour and advice.

But as the moſt eminent amongſt the ancient writers on this branch of natural hiſtory, have propoſed two different manners in which inſects undergo their mutations; one known by the name of Nymph, and the other by that of Chryſalis, calling Nymph that change of the Worm, under which it exhibits the form of the inſect that is to iſſue from it; and Chryſalis, that other change which ſhews no ſigns of the future inſect; I muſt forewarn my readers that I ſhall by no means admit two different ſpecies of changes, as I can plainly and diſtinctly diſcover in the Chryſalis, as well as in the Nymph, all the parts of the future inſect, and can even give ocular proof of their exiſtence. And as to the parts not appearing externally in the Chryſalis as clearly as they do in the Nymph, and the former having a gold colour, which I never obſerved in the latter, it is not a thing of conſequence enough to make me alter my opinion.

But perhaps the reader, as yet a novice in the hiſtory of inſects, may not rightly underſtand what I mean by the words Nymph and Chryſalis, I muſt refer him to the figures of this work, where he will find the Nymph of the Ant repreſented under number v. Tab. XVI. and the Chryſalis of the nocturnal Butterfly, under the ſame number v. Tab. XXXIII. For the ſake of greater perſpicuity, I obſerve the ſame order in Tab. I. XII. and XXXVIII. where I place before my readers other ſpecies of Nymphs that ſhall be deſcribed in their proper places, and afterwards ſummed up under one view, in the general compariſon of mutations, with which I intend to conclude this work. Farewell.

ELEGIA

IN HONOREM

D. JOANNIS SWAMMERDAMII, M.D.

Naturæ Inſectorum Indagatoris indefeſſi, incomparabilis.

Allocutio ad Harveum τ̃ πάνυ.

FLOS & honos Angliæ gentis, quo, judice Phœbo,
Nil quicquam eximius terra Britanna tulit;
Artis delicium noſtræ, quo ſoſpite quondam
Sidera tangebat vertice celſa ſuo;
Deſine jam gemitus, tua jam ſuſpiria ceſſent,
Quod multa abſtulerit ter ſcelerata manus,
Quêis miranda tibi levium ſpectacula rerum
Scripta, atque in varios corpora verſa modos:
Quêis tibi Nympharum & fulvæ Chryſallidos ortus
Depicti, & Gryllus papilioque fuit:
Ecce alium, data damna tibi qui ſarciet olim,
Inventiſque addet non tibi viſa tuis.
Non hunc parva latet magni Formica laboris,
Anguſto quamvis tramite carpat iter.
Hic quis amor, quis Hymen illis, quæque oſcula novit,
Quâ foveant natos ſedulitate ſuos:
Non fugit hunc miſera & male nata Diaria, quamvis
Vix detur medium vivere poſſe diem;
Quæ poſtquam teneris volitavit in ære pennis,
Sævis præda avibus, piſcibues eſca cadit.
Nec Scarabæus aquæ, ſeu pervolat ille paludem,
Seu celer, ad fundum, mox rediturus, abit;
Sed bullâ, mirum viſu! rediturus inani,
Quam villoſa intus caudula cluſa tegit.
Nec tu, dire Culex, mediis ſeu degis in undis,
Aëra ſeu pinna liberiore petis.
Novit Apum ſexus, ortus, connubia, novit
Quam telam in cera ſedula fingat Apis.
Et negat ulla novas Inſecta aſſumere formas,
At vermi incluſas delituiſſe docet.
Quam ſtupui, quando narrantis ab ore pependi,
Cum mihi monſtraret plurima quam ſtupui!
Gaude, Vegta, tuis illum quod vexeris undis,
Et quod capta tuo flumine præda fuit.
Non Aldrovandos jam clara Bononia jactet,
Nec mihi Moufetos Anglus ad ferat:
Geſneros etiam ſileat Germania tellus,
Neſcio quid majus Terra Batava dabit.

Cecini amico amicus

MATTHÆUS SLADUS, M. D.

Ἐις ΣΩΑΜΜΕΡΔΑΜΟΝ περὶ Εφημέρου ἐντόμου
βιβλιόν ἐκδιδόντα.

Πρὸς ἀναγνώστην.

Τήν δ' ὅταν γνῴης καὶ ἀναγνῴης, φίλε, βίβλον,
Σουαμμερδᾶμος τὴν τέκεν εὐφραδέως,
Ἐντόμου ἣ σε φυὴν ἀλλοιώσεις τε δίδάσκει
Ἦμαρ τῷ σφετέρην δώκεν ἐπωνυμίην.
Μὴ καταγινώσκῄς πόνον αὐτοῦ. ἀλλὰ σεαυτὸν
Γνῶθι, καὶ αὐτὸς ἐὼν μάνθαν' ἐφημέριος.

Idem utcunque Latinè redditum.

Ad Lectorem.

Videris ut, Lector, librum & perlegeris, ingens
Quem Swammerdammi cura laborque dedit;
Quo tibi natura Inſecti moreſque pateſcunt,
Unica cui nomen donat habere dies.
Negligere illius curam fuge. Noſcere at ipſum
Te cupe, quamque fugax ipſe breviſque ſies.

M. SLADUS, M. D.

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His Royal Highneſs PRINCE EDWARD.

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THE

THE

BOOK of NATURE;

OR, THE

HISTORY of INSECTS.

CHAP. I.

The deſign and diſtribution of the work.

AFTER an attentive examination of the nature and fabrick of the leaſt and largeſt animals, I cannot but allow the leſs an equal, or perhaps ſuperior degree in dignity. Whoever duly conſiders the conduct and inſtinct of the one, with the manners and actions of the other, muſt acknowledge all are under the direction and controul of a ſupreme and ſingular intelligence; which, as in the largeſt, it extends beyond the limits of our comprehenſion, eſcapes our reſearches in the ſmalleſt. If, while we diſſect with care the larger animals, we are filled with wonder at the elegant diſpoſition of their limbs, the inimitable order of their muſcles, and the regular direction of their veins, arteries, and nerves; to what an height is our aſtoniſhment raiſed, when we diſcover all theſe parts arranged in the leaſt, in the ſame regular manner. How is it poſſible but we muſt ſtand amazed when we reflect that thoſe animalcules, * whoſe little bodies are ſmaller than the fineſt point of our diſſecting knife, have muſcles, veins, arteries, and every other part common to the larger animals? Creatures ſo very diminutive, that our hands are not delicate enough to manage, or our eyes ſufficiently acute to ſee, them; inſomuch that we are almoſt excluded from anatomizing their parts, in order to come at the knowledge of their interior conſtruction. Thus, what we know of the fabrick of thoſe creatures reaches no farther than to a ſimple enumeration of the parts which we have before obſerved in larger creatures. We are not only thus in the dark, in attempting a diſcovery of the conſtruction of the leaſt animalcules, but we even gain very little knowledge of the wonderful texture of the viſcera of the largeſt animals: for as the point of our diſſecting knife is not minute enough to ſeparate the tender parts of the ſmall animals, it is not leſs unfit to be uſed in diſcovering the extremities of the nerves and veins in the larger.

As our knowledge of both ſpecies of animals is ſo far limited by our ignorance, and as we have not hitherto had ſuch a ſufficient number of experiments as are neceſſary to form a proper judgment of their elegant ſtructure, and the admirable diſpoſition of their parts, we may eaſily ſee how raſh and precipitate their opinion is, who eſteem the larger creatures only as perfect, and the leſs as ſcarce worthy to be claſſed with animals; but, as they ſay, produced by chance, or generated from putrefaction; rendering, by ſuch reaſoning, the conſtant order of nature ſubject to chance. But as it happens to the ſmalleſt of animals, for inſtance, to thoſe produced from the egg of the Acarus which is ſo minute, as ſcarcely to be viſible, ſo alſo it is with the largeſt animals; their origin is not more obvious or more viſible, perhaps it is rather more obſcure, and they derive their being from a leſs viſible beginning. Nor let any man imagine that I ſay this without conviction, ſince I have found by diligent inquiry that the largeſt animal is not in its firſt formation bigger than the rudiment of an Ant; and therefore, unleſs the Great Creator had ſet certain bounds to the growth of every kind, which it cannot exceed, I ſee no reaſon why the Ant might not ſurpaſs in bulk the largeſt. Perhaps, their ſizes proceed in proportion to the greater or leſs ſtrength of the heart, by which the parts muſt be extended, againſt the preſſure of the atmoſphere. Notwithſtanding the ſmallneſs of

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* We are accuſtomed to uſe the word animalcule, to expreſs thoſe minute creatures in particular, which are only ſeen by the aſſiſtance of microſcopes; this author applies it to ſmall animals in general, which was its original, and is its more proper, meaning.

Ants, nothing hinders our preferring them to the largeſt animals, if we conſider either their unwearied diligence, their wonderful ſtrength, or their inimitable propenſity to labour; or, to ſay all in one word, their amazing and incomprehenſible love to their young, whom they not only carry daily to ſuch places as may afford them food, but, if by accident they are killed, and even cut into pieces, they, with the utmoſt tenderneſs, will carry them away piecemeal in their arms. Who can ſhew ſuch an example among the largeſt animals, which are dignified with the title of perfect? Who can find an inſtance in any other creature, that may come in competition with this? But in the entrance of this work it is not my intention to explain the form and wonderful propagation of animalcules, which ſeem to be exanguious or to have no blood: I ſhall treat in general of the manner of their ſurpriſing metamorphoſes; and at the ſame time ſhew, that they not only reſemble other animals in the increaſe of their parts, but that they exceed them by infinite degrees. This being done, the particular obſervations concerning thoſe animalcules ſhall be fully explained in their proper order and place. But before I proceed to them, it will be neceſſary to prefix a general diſſertation on their nature.

That I may make good the promiſe which, twelve years ago, I made to the public in the preface to my book of Reſpiration, (and which I have been unhappily hitherto hindered from fulfilling by ſickneſs, and other impediments,) I am now to ſhew the particular change of the Caterpillar into a Chryſalis; as alſo, the nature and various forms of thoſe animalcules, which are ſaid to be exanguious, before and after their change into Nymphs: but I judge it extremely neceſſary to eſtabliſh firſt ſome certain propoſitions, and to explain the order of their changes. This, fully underſtood, will contribute to a clear and diſtinct perception of the irregular and various appearances of inſects; ſupplying the place of a pencil, and repreſenting, as it were, in their true colours, the variations of them; ſetting each in a juſt light, and in their native dreſs. Thus ſome certain and fixed principles will be ſupplied to the ingenious, who are curious in theſe things; and the obſervations, of which I ſhall give a conſiderable number, will remain as a firm foundation and ſure ſupport for all thoſe experiments that ſhall be made concerning them, or all that poſſibly can be made. Nor does it appear to me a matter of ſmall moment to have diſcovered rules and theorems in the nature of things, by the aſſiſtance of which all thoſe metamorphoſes of inſects, which have the appearance of fiction and fancy, and differ in form and ſtructure infinitely from each other, are reduced to one foundation and kind only; including in three or four orders of changes all the various ſpecies. This may be perceived in the firſt rudiments of thoſe creatures which appear to us under the form of eggs.

The true nature of the metamorphoſes of theſe animalcules ſeems to have been ſubject to the fate of ſome valuable picture, which, by length of time, being ſoiled and clouded with dirt, no longer ſhews the true form of its figures, but has an appearance altogether different; ſo that it muſt be cleaned, and its original luſtre reſtored, if we would diſcover its true appearance. In the ſame manner here, before we can explain the poſitions and the ſeries of the changes, and illuſtrate them by particular examples, it is neceſſary we ſhould reſtore this excellent appearance, or, if I may ſo ſpeak, that curious picture, exhibiting the natural forms of inſects: which, by the learned as well as others, through length of time, has been ſo ſoiled and obſcured, that the beautiful and genuine changes of thoſe animalcules do not appear properly what they are, but rather ſomewhat elſe, or at leaſt, are ſeen in a confuſed manner. Theſe muſt therefore be cleared from the falſe traditions of philoſophers, by our theorems, as by the genuine tinct of nature, and reſtored to their native beauty.

We ſhall now proceed to the four diſtinct things which are to be treated of in this work. In the firſt place, we ſhall conſider the Nymph as the original ground of all the transformations of inſects, or exanguious animals; but, leſt any one ſhould miſtake the uſe of the word transformation, I here add, that both in this, and in every other part of the enſuing work, I intend no more by that term, than the gradual and natural growth of thoſe creatures. Secondly, we ſhall ſhew by what means it has happened, that the knowledge of the Nymph, or original ground of thoſe natural changes, has been ſo obſcured and darkened. This we ſhall take care to clear up and reſtore to its former ſtate. Thirdly, we ſhall eſtabliſh four ſeries or orders of thoſe changes, taken from nature, to which all the metamorphoſes of the exanguious animalcule may be referred, as depending only upon one foundation. Laſtly, the order of the natural changes of their parts will be confirmed by particular examples in the inſects themſelves, together with the figures of them, and the whole clearly and diſtinctly explained.

CHAP. II.

The ſingle foundation of the changes obſervable in the known inſects ſhewn to be the Nymph; with an explanation of the manner in which worms and Caterpillars become Nymphs.

THOUGH, amongſt all the mutations of nature which deſerve our attention, none appears more ſurprizing to the generality of mankind, than that by which a Caterpillar aſſumes the form of a winged animal, it in reality deſerves no more admiration, than any other change in the forms of Bees, or the transformation obſervable in plants. This will evidently appear to any one, who, having examined the real nature of ſuch metamorphoſes, will obſerve how exactly they agree, not only with the growth of animals which undergo no ſuch change; but alſo with the ſhooting or budding out of plants and flowers. Whatever difficulty we find in this, is merely an effect of our own miſtaken notions; and our admiration ariſes from our ignorance of the nature of the Nymph or Chryſalis. In this the little animal lies, like the flower in its bud. Before I proceed farther on this head, it may be proper to obſerve, that theſe words, Nymph and Chryſalis, ſignify the ſame thing, and that there is no difference in the nature of the ſubjects to which they are applied.

To advance toward my purpoſe, I muſt repeat, that the reader is to take particular notice, that to acquire a ſatisfactory knowledge of the mutations which happen in the eggs of inſects in general, as well as in the worms or Caterpillars in particular hatched from them, he muſt firſt clearly and diſtinctly comprehend the nature of the Nymph, Necydalis, Chryſalis, or Aurelia. Though we muſt allow that there appears, as it is generally called, ſome accidental difference between the plain unadorned Nymph, and that form of it, which, from its bright gold colour, is called an Aurelia, or Chryſalis; upon muture conſideration, this will be found merely accidental, without any difference in the internal conſtitution of their parts, ſufficient to alter in them what is commonly called the eſſence of things. This great truth being once underſtood of inſects in general, may be afterwards applied to every particular ſpecies of them: for inſtance, to the Silk-worm, whoſe Nymph or Necydalis is never called Nymph by naturaliſts; but only Necydalis and Chryſalis, though it is in fact a Nymph, and is called Chryſalis merely on account of the external difference in colour.

That we may ſucceed the better in examining the nature of this Nymph, or Chryſalis, upon which, as upon an immoveable baſis, the doctrine of all the changes obſervable in inſects is ſo evidently founded, that the jarring opinions of all the naturaliſts who have hitherto wrote upon the ſubject, muſt appear utterly vain; it is neceſſary to obſerve, that the Nymph, or Chryſalis, is nothing more than a change of the Caterpillar or worm; or, to ſpeak more properly, an accretion, growth, or budding of the limbs and parts of the Caterpillar or worm, containing the embryo of the winged animal that is to proceed from it. The Nymph, or Chryſalis, may even be conſidered as the winged animal itſelf hid under this particular form. From whence it follows, that in reality the Caterpillar, or worm, is not changed into a Nymph or Chryſalis; nor, to go a ſtep further, the Nymph or Chryſalis into a winged animal; but that the ſame worm or Caterpillar, which, on caſting its ſkin, aſſumes the form of a Nymph or Chryſalis, becomes afterwards a winged animal. Nor, indeed, can it be ſaid that there happens any other change on this occaſion, than what is obſerved in chickens, from eggs which are not transformed into cock or hens, but grow to be ſuch by the expanſion of parts already formed. In the ſame manner the Tad-pole is not changed into a Frog, but becomes a Frog, by an unfolding and increaſing of ſome of its parts.

Hence it follows, that in the Aurelia, and more particularly in the Nymph, ſo called by Ariſtotle* with the greateſt propriety, there are not only all the parts and limbs of the little winged animal itſelf; but, what is more ſurpriſiing, though 'till now unnoticed by any author I have met with, all theſe parts, or limbs, are to be diſcovered, and may be ſhewn in the worm itſelf, on ſtripping off its ſkin in a careful manner. If therefore we retain the name of Nymph, uſed by Ariſtotle, the worm at this period may be conſidered as marriagable, and, if we may make uſe of theſe expreſſions, entering into the connubial ſtate. We may further ſhew this, by conſidering that the worms, after the manner of the brides in Holland, ſhut themſelves up for a time, as it were to prepare, and render themſelves more amiable, when they are to meet the other ſex in the field of Hymen. Since therefore the word Nymph expreſſes the nature of the thing better than any other, as will more clearly appear hereafter, we ſhall adopt it on this occaſion to avoid confuſion, and to be the better underſtood: for though the words Chryſalis and Aurelia are employed to expreſs the ſame thing, they properly imply ſome external differences, which we have already named, and ſhall hereafter treat of more at large.

That elegant diſpoſition, and diſtinct framing of parts, which I have mentioned, is particularly obſervable in the Nymphs of Ants, Tab. XVI. No. v. Flies, Tab. XLI. fig. 11, and Bees, Tab. XXV. fig. VI. as will appear upon inſpecting their figures in Tab. XVI. XLI. and XXV. For ſome accidents, as they are called, ſuch as colour, firmneſs of the parts, and the like excepted, theſe Nymphs repreſent exactly, and in a ſurpriſing manner, the little winged animals they are to produce; and even in the ſpace of two or three days after they have caſt a very thin ſkin, all thoſe parts appear in moſt of them.

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* Hiſt. Anim. Lib. V. cap. 19.

This accurate agreement, or rather this ſameneſs of the Nymph with the little animal it covers in the preſent form, has given room to ſome who have written on this ſubject, to call the Nymphs of Ants, Flies, and Bees, by the names of Ant-ſhaped, Fly-ſhaped, and Bee-ſhaped Nymphs. This we ſee in Ariſtotle, in the place above cited: He ſays, "When they "have received the out lines of the ſhape which "they are afterwards to wear, at this period "they are called Nymphs." Even the learned Mouffet, though in his book of Inſects he beſtows a particular chapter upon the Chryſalis, there denies that any diſtinct parts are to be obſerved in it, yet is not to be underſtood as including the Nymph in that aſſertion; he does not even make the leaſt mention of it: and, indeed, thoſe diſtinct parts are ſo evident in the Nymphs of inſects, as ſcarce to leave the leaſt room in any to doubt, but that they are the very animal which they ſo evidently repreſent. This certainly muſt be the reaſon why the Nymphs are often call'd Chryſallides and Aureliæ by the ſame author, in the courſe of his work; though no deſcription is given of them in the chapter we have here named.

As errors never are confined to thoſe who firſt fall into them, the incomparable Harvey *, by committing the ſame miſtake with Mouffet in his notions concerning the nature of the Chryſalis, has ranked the Nymphs of the Bees in the number of them. With the ſame Mouffet, Ariſtotle and Aldrovandus have explained the difficulties which occur in following, by a nice examination, the tranſmutations of this claſs of inſects, by a ſyſtem more ingenious and ſubtil, than agreeable to truth and the nature of things; ſince both he and Ariſtotle †, Aldrovandus, and numbers of other authors, have imagined, that the Nymphs of Bees are ſo far from containing the parts of the future inſects; that they can only be looked upon as the eggs which are to produce them.

Tho' there are ſome ſlight external differences between the Nymph and Chryſalis, which we have already obſerved, the Chryſalis notwithſtanding ought to be conſidered as a Nymph; there are alſo ſome external differences amongſt the Nymphs themſelves, which it is likewiſe proper to take notice of in this place. Thus, there is by far a greater agreement between the Nymph of the common Ant and the Ant itſelf, than there is between the Nymphs of Bees, or of Flies, and theſe winged inſects reſpectively; ſo that there appears the ſame diſagreement between Nymphs of one kind and another, as between theſe and Chryſallides. But as all theſe differences are merely accidental, as will hereafter more plainly appear, little regard is to be paid to them; notwithſtanding Ariſtotle, who at the ſame time that he aſſerts a ſimilitude, in point of ſhape, between the Nymphs and the little animals to be expected from them, ſo far denies ſuch a property in the Chryſallides, that he repreſents them merely as the eggs of thoſe inſects to which they belong ‡.

That we may treat more accurately of the Chryſalis, or Aurelia, which is indeed nothing more than a gold-coloured or gilded Nymph, and neither is nor ought to be called ſpecifically or diſtinctly by this name, nor can at all times, ſeeing all the Nymphs which are called Chryſallides have not this bright outſide; this Chryſallis, I ſay, in the ſame manner as has been ſhewn of the nymph, "not only contains all "the parts of the future animal, but is indeed that animal itſelf". This truth, however, is contradicted among the antients by Ariſtotle, and among the moderns by Harvey, and numberleſs other writers. As we have obſerved that the Nymph of the Ant differs from that of the Bee; and this laſt from the Nymph of the Fly; we remarked alſo, that the Nymph generally known by the name of a Chryſalis, differs from all thoſe beforementioned. That this may appear the plainer, for example, in the caſe of the Butterfly's Chryſalis, Tab. XXXV. fig. VI. and VII. it will be proper regularly to demonſtrate, not only the differences by which the Nymphs of the Ant, Bee and Fly may be diſtinguiſhed from one another's, but thoſe variations likewiſe by which the Butterfly's Chryſalis is diſtinguiſhed from theſe Nymphs; and the differences alſo, by which all theſe Nymphs and Chryſallides vary from the inſects they are to produce. By this means we ſhall be enabled to attain a perfect idea of that moſt remarkable property, by which they perfectly agree with each other. This property we affirm to conſiſt in an exact repreſentation of the future animal, and of all its parts.

The firſt property then, by which the Nymph of the Ant, Tab. XVI. No. V. agrees better with the Ant, than the Nymphs of Flies, Bees, or Butterflies, do with thoſe inſects reſpectively, and by which property, of courſe, the Nymph of the Ant differs from the Nymphs of the three other inſects before-mentioned, conſiſts in this; that the common Ant, which has no wings, but only antennæ, or horns, and legs, affords as clear and diſtinct a repreſentation of thoſe parts, when hid under the form of a Nymph, as when it afterwards appears in its own proper and perfect ſhape; excepting only, that the legs and horns, which in the Nymph are folded up in a delicate manner, ſhew themſelves at large, and in another ſituation, in the Ant itſelf. So that the different diſpoſition of theſe parts, in the ant and its Nymph, which every one muſt allow to be an article of little conſequence, conſtitutes all the difference that there is between them. Nevertheleſs, the overlooking of this truth, the moſt important of all in the theory of inſects, in the caſe of their Chryſallides, has been the great reaſon why the true knowledge of the nature of this ſpecies of Nymph has been buried to this time in obſcurity, to give way to a fancied metamorphoſis.

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* In Lib. Gener. Anim. Exerc. 1.

† In Lib. ii. Cap. 5. de Chryſallide.

‡ Hiſt. An. Lib. v. Cap. 19.

The other difference, or that which is remarkable in ſhape between the Fly, Tab. XLI. fig. II. and its Nymph, and between the other inſects already mentioned, and theirs, conſiſts chiefly in this, that the wings which in the common, or more ſcarce Fly, appear ſtretched out and expanded over the body, are folded up in the Nymph, and lie cloſe along its ſides, and between its legs. This is alſo the caſe in the common Ant; whereas both in the Fly and its Nymph, the horns, and proboſcis or trunk, are almoſt the ſame in every reſpect.

The third difference, or that which is obſerved between the Bee and its Nymph, Tab. XXV. fig. VI. and the inſects already named, and their Nymphs, is this, that the legs and Nymph of the Bee, which, beſides horns, has four wings, and a little trunk turned up towards its body, carries thoſe parts in a different poſition, from that wherein they are ſeen in the Bee itſelf, and in a manner which makes it difficult to diſcern them. The wings, like thoſe of the common Fly, Tab. XXXVIII. fig. IV. are folded up, and lie cloſe along its ſides, and between its legs; but the little trunk, ſo difficult to be obſerved in the common Fly and its Nymph, is very conſpicuous in that of the Bee, where it lies delicately diſpoſed between the contracted legs of the embryo.

As therefore all the parts of theſe Nymphs may be eaſily diſtinguiſhed in them, though occaſionally with ſome accidental differences; ſo one thing is equally common to all of them, namely, that each of them clearly expreſſes the inſect which is to be expected from it, or is rather already that very inſect; which in the manner of the Caterpillar, the better to explain the difference between the Nymph and the future inſect, is now preparing to caſt off a ſkin, to become from a Nymph, a winged animal; in the ſame manner as it had caſt one off before, from a Worm, to become a Nymph. Theſe operations of nature Libavius* has ſufficiently explained in the Silk Worm, and faithfully repreſented in his elegant drawings.

It is, moreover, worthy to be obſerved, that the legs, wings, trunk, horns, and every other part of the animal, are covered with a membrane of equal thickneſs, in every place where they do not lie upon each other. This is the reaſon why, in the Nymphs of inſects, almoſt all the members appear free, flexible, and capable of motion; for there is a ſpace between all theſe parts acceſſible to the air; and they neither touch, nor can adhere to one another. This alſo is the reaſon, why the free ſpace produces a ſlight ſhade between ſome of the parts, affording the curious eye an opportunity of determining exactly the figure of the inſect's little body, and all its limbs; to this cauſe alſo, we are to attribute, that the Nymphs become of a particular colour, as ſoon as they have gone through their neceſſary change, and appear of a perfect milky whiteneſs.

In the Chryſallides, ſome of which, like the other Nymphs, aſſume this milky hue at the time of their change, but afterwards become ſpotted with gold, or entirely cloathed in that rich colour, it is a more difficult matter, on a bare ſurvey of their outſides, to diſtinguiſh the parts of the inſect one from another. Their legs, wings, and the reſt are folded up, and as it were packed together in a moſt intricate manner: and this difficulty has been the cauſe, as will be hereafter ſhewn, of the principal miſtakes of writers on this ſubject.

It is likewiſe worthy to be obſerved, that the Nymphs of all the three inſects we have here taken notice of, the Ant, the Fly, and the Bee, immediately after their change become tender and flexible, and indeed fluid, in a manner like water itſelf; ſo that they loſe all their former ſtrength and vigour: this made Gaza, with great reaſon, call them invalids, as the learned Aldrovandus has obſerved, ſince they remain in this condition almoſt to the end of this period of their life. Mouffet ſeems to have taken notice of this ſoftneſs in ſome Chryſallides, the cauſe of which we ſhall explain in its due place, with the neceſſity there is for it. That author's words are, † "When Pliny ſays that "the body of the Chryſalis is hard, I imagine he "means the Caterpillar." The ſkins which are thrown off by the Nymphs here mentioned, are ſo twiſted and folded together, that, without a delicate hand, and a great deal of experience, it is a hard taſk to diſplay them properly; this will appear when we come to relate our obſervations upon Bees, the curioſity of which has a right to command the admiration of mankind.

We now proceed to the fourth difference, or that which belongs peculiarly to the Chryſalis, and, like the reſt, is only accidental, though a great deal more remarkable. That the reader may know what Chryſalis we are about to compare with its Butterfly, and afterwards with the Nymphs of the Ant, and the Fly and the Bee, and, laſtly, with theſe inſects themſelves; we are to inform him, that we ſhall take for our preſent example that Chryſalis, of which Mouffet ‡ gives a drawing in number XII of his diurnal Butterflies, which is the ſame with that deſcribed by Goedaert, in the twenty-firſt experiment of his firſt part, and which I have repreſented ſeveral ways in Tab. XXXV of this work.

The difference between this Butterfly and its Chryſalis, as well as between the other Nymphs heretofore mentioned, and their animacules, is as follows. The wings, which in the Butterfly ariſe from the ſhoulders, are very large, and hang over the back of its body, in the Chryſalis, Tab. XXV. fig. VII. are gathered up and folded into the ſhape and ſize of half the nail of a man's little finger, and are turned in towards the belly, againſt which they lie of an equal thickneſs, *m m*.

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* Obſ. Hiſt. Bomb L. I. C. 21.

† Inſ. Th. L. II. C. 36. de Aurel.

‡ Inſ. Th. L. I. C. 14.

The trunk, which in the Butterfly is contracted and curled up into the ſize and ſhape of the head of a ſmall pin, and lies between its wings, appears in the Chryſalis beautifully expanded along its belly, between the two wings *d d*. In the Chryſalis alſo, the legs, *f f*, *g g*, by a moſt inimitable contrivance, the cauſe of which, with the reaſons for it, we ſhall hereafter deliver in our ſelect experiments, which are placed on both ſides cloſe to the trunk, quite otherwiſe than in the Butterfly; and finally, to compleat this ſcene of wonders, the horns, *i i*, which in the Butterfly are ſtretched out at full length over the eyes, lie over the legs in the Chryſalis; ſo that upon the whole, all the parts of the inſect, the body, wings, horns, legs, and trunk, are to be found as well in the Chryſalis, as in the Nymph, in the former, indeed, the feet are leſs diſcernable than in the latter; but the ſame difference is equally obſervable in the reſpective inſects.

The ſkin which contains the Chryſalis, is much thicker in thoſe parts which cover the limbs on the outſide, than in thoſe which ſerve only to keep them aſunder; beſides, all theſe parts are ſo evenly and elegantly faſtened as it were to and upon one another, that they exhibit an uniform and equable contiguity of parts. For this reaſon they are, with the greateſt difficulty, to be diſtinguiſhed from one another, and that only by a ſingular method, which I ſhall explain to the reader in its proper place. This difficulty not only prevented Mouffet from giving us an accurate repreſentation of the Chryſalis in the place juſt cited *, but induced him to deny, with Ariſtotle, that there are any parts in the Chryſalis diſcernable by our ſenſes. He ſays, "the Chryſalis has neither mouth, nor any other part of the ſucceeding inſect, that can be perceived."

Libavius, is under as great a miſtake on this ſubject †; for, though in treating of the Necydalis, he allows it ſome traces of wings, and alſo of horns, he denies that any diſtinct limbs are obſervable in it; his words are theſe, "On the fore part there are marks of legs and horns; and on the back part, towards the ſides, ſome faint repreſentations of wings." But a little afterwards he ſays, "You cannot perceive any diſtinct limbs."

Goedaert is as much at a loſs as theſe authors, about the true nature of the Chryſalis. He is at great pains to make out in it ſome reſemblance of the human face; and he gives a drawing of it, under this idea, in his figures of chryſallides. He ſhould rather have given us that elegant form, which really appears in the Chryſalis, than have endeavoured to amuſe his reader with idle ſpeculations, the more productions of his own fancy. Nor is this all his error; he gives us an unnatural repreſentation of the caterpillar itſelf, in the place already cited; for that Caterpillar is not covered with hair, but with little prickles, and is very nearly of the figure repreſented in his 26th experiment.

As the limbs of the Chryſalis, faſtened together in the manner already mentioned, harden by degrees, or its ſkin, which at firſt was ſoft and tender, gradually dries up, and becomes, as it were, of a horny ſubſtance, it gradually alſo changes the greeniſh hue which it had before, for a gold colour, and all the parts loſe their motion; till at laſt this Chryſalis, or properly the Butterfly, which has lain its time under the form of this Chryſalis, caſting off its hardened ſkin, breaks forth in the very ſhape in which it lay hid under it, without having ſuffered any change during its confinement, unleſs this, that its tender parts, which were fluid like water, and immoveable, through an exceſs of humidity, have with time acquired firmneſs and ſtrength; juſt as it happens in the Nymphs already deſcribed.

When the Chryſalis has caſt off its skin, the wings viſibly expand to their true dimenſions in a moſt ſurpriſing manner; and the legs and other limbs unfold themſelves, and aſſume the direction and form we ſee in the Butterfly ‡.

This expanſion of the wings being very ſudden, and therefore difficult to be juſtly obſerved, or underſtood as it deſerves, unleſs by perſons accuſtomed to experiments of this kind; it is no wonder that the moſt happy geniuſes, the immortal Harvey, for example, and numberleſs others, ſhould have fallen into an error on the occaſion, affirming that this metamorphoſis is not external, or occaſioned by any growth in the wings of the Chryſalis; but that it is altogether internal, not only in regard to the wings, but to all the other limbs; inſomuch that Harvey takes upon him to ſay, that the Chryſalis aſſumes a new form in every reſpect, and therefore calls it a perfect egg. The truth is, this ſuppoſed transformation does not take place either internally or externally in the Chryſalis; this is proved by the moſt careful experiments, with which his doctrine totally diſagrees. Nor does he ſucceed better in explaining, than he had, in imagining this metamorphoſis, which by his denying any growth of the parts, and ſubſtituting an imagination of his own, becomes utterly incomprehenſible. Theſe remarks are to be conſidered here as occaſionally introduced; for as we intend to deſcribe in our ſelect experiments, the manner in which theſe wings and the other limbs grow, and to demonſtrate alſo what changes happen from day to day in the egg and Chryſalis of the inſect, both of which we have found to be of the ſame nature, till the Caterpillar iſſues from the former, and the Butterfly from the latter, we ſhall at preſent enter no further on this ſubject.

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* Inſ. Th. L. II. Cap. 36. de Aurel.

† Obſ. Hiſt. Bomb. L. I. Cap. 21.

‡ The time in which a Butterfly remains in the Chryſalis ſtate, is not limited by nature to any particular period, but depends on external accidents. Reaumur fancied that he could keep the Chryſalis entire many months beyond the uſual time of the diſcloſure of the inſect, and thus add to the length of the creature's life, though in a condition wherein it had little enjoyment.

Let any one attentively conſider theſe accidental differences, by which the Nymphs of inſects differ amongſt themſelves; the Chryſalis from its Butterfly, and the other Nymphs from their reſpective inſects heretofore mentioned; as alſo, thoſe qualities by which the Nymphs agree both with their animalcules, and amongſt themſelves; and he will plainly perceive, that the Nymph and Chryſalis do not differ in the leaſt in this nature, or as to the interior conſtitution of their parts, ſince both diſtinctly and exactly repreſent the form of the inſect, which is to be expected from them. We allow this repreſentation to be more diſtinct and obſervable in the Nymph, than in the Chryſalis; but even this depends in a great meaſure upon the good ſight and dexterity of the obſerver. An indefatigable examiner muſt at laſt reach the deepeſt myſteries of this ſcience; and thus an aſſiduous application has rendered it familiar to me to exhibit, in every ſpecies of Chryſalis, all the parts of the ſucceeding inſect. But, leſt any oppoſer ſhould take it into his thoughts to object with the great Harvey, that there is in this caſe a perfect egg, which time may transform, and to which it may give limbs, we can anſwer, that we can perform this operation equally at different times, in the very inſtant of the change, or in the beginning, as eaſily as in the middle and end of it; and even on the very Worm, before it becomes a Chryſalis. There is no kind of Chryſalis, (however ſtrange, unnatural and ludicrous the the figures may be, which Goedaert and others have found out for them, in the wild ſallies of their imaginations) in which we are not able to demonſtrate all the parts of the future inſect; and this as evidently, as in the true Nymph. It appears therefore to be beyond all doubt, that the Chryſalis differs from the Nymph only in colour, and the diſpoſition of its parts, or, as the philoſophers term it, *per accidens*.

But it will be asked, perhaps, how it happens that limbs ſhould be more conſpicuous in the Nymph, which is evidently the very inſect itſelf, than in the Chryſalis, though equally worthy of that name? and why, in the latter, the parts are not ſo faſtened, as it were, to each other, as in the former. It may be demanded alſo, for what reaſon the skins caſt by the Nymph ſhould be much thinner, than thoſe thrown off by the Chryſallides, which part with theirs in the ſame manner that the chicken leaves the ſhell of its egg. To all this I can only anſwer, that theſe things are hardly, if at all explicable; the nature of them depending entirely on the pleaſure of their Creator; and the reaſons of this variation being hidden in his impenetrable wiſdom, whoſe providence has beſtowed on his animal productions as great a variety of cloathing, as it has pleaſed him to form diſtinct ſpecies of ſuch beings. It appears therefore that in theſe and other as true reſearches, we ſhould endeavour, by all means, to explain difficulties by reaſons drawn from the nature of things themſelves, not from the ſcanty ſtorehouſe of our imaginations. Otherwiſe, by deviating though ever ſo little from that rule and order, which is firmly eſtabliſhed throughout the whole creation by the all-wiſe, and powerful author of it, it is impoſſible we ſhould not go aſtray at every ſtep, and loſe ourſelves at laſt in the wrong paths, directed by our own feeble and imperfect reaſon.

As the foregoing queſtions deſerve great attention, I ſhall propoſe that ſolution of them, which nature herſelf ſeems to authorize and ſupport. We may obſerve, that the Nymph of Ants, Flies, and Bees have a much ſlenderer body than the Chryſalis before ſpoken of; and from this it appears reaſonable to ſuppoſe, they ſhould have a much tenderer skin. The Nymphs, beſides this, are always confined to moiſt places, where their exterior covering cannot readily harden: do not the Nymphs of Ants lie hid under the earth? and thoſe of Flies in putrid fleſh, the excrements of animals, and other moiſt places. As for the Nymphs of Bees, they are always found ſurrounded with moiſture, incloſed in wax, and covered beſides, like Silkworms, with a thin membrane: beſides this the Nymphs of Bees, at the time when they enter upon their period of change, have all their parts ſo exceſſively moiſt, that ſometimes they weigh twice as much as the Bees that are produced from them.

It is obſervable, indeed ſurpriſing, that the humours conſtituting this moiſture muſt be diſſipated by inſenſible perſpiration, before the milky limbs of the inſect can move themſelves in the leaſt; and all this while the creature diſcharges no excrement. This Ariſtotle has remarked in expreſs words *.

On the other hand, the Chryſallides of diurnal Butterflies (I ſpeak here in general, and do not confine myſelf to one kind of Chryſalis) go through their changes in the open air, with the greateſt part of their bodies deſtitute of any webb to protect them againſt the inclemencies of the weather; for this reaſon their outer ſkin will naturally grow hard, and therefore may be caſt off, as has been already taken notice of, without being liable to ſhrink up, or loſe any thing of its original form. Beſides, the ſkin of the Horned Beetle, Tab. XXVIII. fig. VI, VII, VIII, which is likewiſe found under the earth, is ſo very fine, that in point of thickneſs it is greatly exceeded by the coat of the common Chryſalis.

If any one ſhould aſk, if it is for the ſame reaſon that the Chryſalis itſelf grows hard, and the Nymph continues in its former ſtate of of ſoftneſs? and why, on the one hand, the Nymph is covered with a thin ſkin, and its limbs adhere but little to each other; whereas, on the other hand, the Chryſalis is ſurrounded by a kind of hard ſhell, and all its parts are in a manner faſtened together, ſo as to form one ſubſtance? I muſt acknowledge, that I cannot ſatisfy his curioſity. For as the Nymphs of Bees, when expoſed to the open air, die as ſoon as it begins to harden their ſkin; and on the contrary, the Chryſallides fare no better when confined to a moiſt ſituation; I cannot be brought to think, that things, which are produced by nature every year, in a moſt wiſe, regular, and conſtant manner, ſhould be left ſo dependant upon chance, and the ſtate of the air and weather: I willingly grant, however, that it is moiſture alone which hinders the Nymphs from growing hard, and that the Chryſallides cannot but harden in an open, airy, and dry ſituation. But if, after all, we conſider, that the ſkin in which the Chryſalis is wrapped up, is not throughout of the ſame ſtrength, but thicker in thoſe parts which are expoſed to the air, than in thoſe which are out of the reach of its influence, as ſerving only to cover the inner ſurfaces of its members; whereas it is the reverſe in the Nymphs, whoſe covering is throughout nearly of the ſame thickneſs, and therefore leſs able to protect the encloſed inſect from the drying quality of the air; theſe things, I ſay, being duly conſidered, I cannot by any means allow, that the preſervation of moiſture, or the hardening of the Nymphs and Chryſallides, juſt taken notice of, depend at all upon chance; unleſs I ſhould be ſatisfied to give up my reaſon ſo far as to imagine, that the very being of theſe little animals depends upon chance likewiſe; and that they ſpring ſpontaneouſly from corruption; and in this blind manner wilfully doubt of nature's great attention and wiſdom, ſo conſpicuous in her manner of preſerving and cloathing this part of the creation. I conclude, from all this, that there is no eſſential difference between the Nymph and the Chryſalis; and that the variation which appears, conſiſts only in this, that the ſkin of the former is more thin and tender, and that of the latter thicker and harder; to which I may add, that in the Nymph all the parts of the future inſect may be eaſily ſeen, whereas in the Chryſalis they are leſs diſtinct. That theſe are the principal differences, will appear evidently hereafter, when I treat thoſe ſubjects ſeparately, and in a more ample manner.

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* Hiſt. Anim. Lib. V. Cap. 19.

The manner in which Worms and Caterpillars become Nymphs.

HAVING laid down the ſole foundation of all thoſe changes which are obſervable in inſects, and ſhewn that this conſiſts in nothing but the Nymph, into which, at their proper ſeaſons, all the Worms of flying inſects and Caterpillars are changed, or, to ſpeak more properly, from which they ſhoot out or bud; a change which appears in all, except ſuch inſects as remain in their eggs, till, without paſſing through any intermediate ſtate, they have acquired their full vigour, and attained their proper degree of perfection; to which may be added, thoſe inſects alſo, which, hiding the real ſhape of the Nymph under the reſemblance of an egg, iſſue from it complete animals, as ſhall be hereafter explained. Theſe things being proved, it appears neceſſary that, before we paſs to the other propoſitions, we ſhould enter upon and explain the manner in which this change is produced, illuſtrating it with the figures of thoſe inſects that are the ſubjects of it.

But as in the forms of thoſe inſects which ſhoot out or bud into Nymphs, there is not only an amazing, but in a manner an infinite variety; and conſequently it would be impracticable here to deſcribe them all; I ſhall particularize only thoſe, which differ moſt remarkably from each other, and conſider them as they have, or have not legs.

We obſerve, that of thoſe inſects which become Nymphs or Chryſallides, ſome have no legs, Tab. XVI. fig. II. ſome have ſix, Tab. XXVII. fig. V. and others a greater number, Tab. XXXIV. fig. II. and Tab. XLIV. fig. III. And as this difference between the various ſpecies of inſects is particularly remarkable, if we compare them together; ſo there occurs a no leſs obvious difference on account of the various number of legs in thoſe we have ranked under the third ſpecies, viz. that of inſects which have more than ſix: but in theſe many feeted inſects, the ſix foremoſt deſerve our chief attention, as does in the inſects that have no legs, that part of their body, which in other animals is called the cheſt.

That it may appear upon what grounds we have adopted this method of claſſing inſects, according to their having or not having legs, and according to their having ſix or more, it will be very proper to obſerve, that in thoſe Worms which have no legs, that part of them, which we have called their cheſt, never undergoes any change, or alters its ſituation; and that in the Worms and Caterpillars which have legs, be the number more or leſs, the ſix foremoſt never come off, or change their places in any ſenſible manner; Goedaert, in direct oppoſition to truth, would have us believe they do, but experiments ſhew the contrary. In moſt Worms and Caterpillars, not to ſay in all, the ſix foremoſt legs are conſtantly preſerved by the inſect, and that without the leaſt change in their poſition: and what is yet more ſurpriſing, in ſeveral Worms which have ſix legs, the alteration in their legs is ſo ſmall at the time that they ſhoot out into Nymphs, Tab. XX. fig. V. that it cannot by any means be diſtinguiſhed or obſerved, whatever metamorphoſes the former naturaliſts, without any exception that I know of, have idly and extravagantly imagined on this occaſion.

As therefore the experiments we have made, have, like the riſing ſun, diſſipated this thick and dark cloud of imaginary metamorphoſes, the whole truth thereby appearing in the cleareſt and moſt evident light; in the ſame manner, by purſuing the ſame cauſe, with that readineſs and confidence which ſuch guidances deſerve, we ſhall readily underſtand the moſt obſcure and difficult changes which happen in thoſe inſects that have no legs. As we have reſolved in this work not to depend upon inductions of one thing from another to prove the aſſertions, we ſhall abide firmly to the chain of our experiments, and, in conſequence of this method, advance, that the wings, horns, and other parts which Worms without legs ſeem to acquire about their cheſts, at the time of their mutation, are not truly produced, during the period of mutation, or, to ſpeak more agreeably to truth, during the time of the limbs ſhooting or budding out; but that they have grown there by degrees under the ſkin, and as the Worm itſelf has grown by a kind of accretion of parts, and will make their appearance in it upon breaking the ſkin on its head or its back, and thereby give it the figure of a Nymph, which it would afterwards of itſelf aſſume, Tab. XXV. fig. v.

Hence it is, that we can with little trouble produce the legs, wings, horns, and other parts of an inſect, which lie hid under its ſkin while in the ſhape of a naked worm, which has neither legs nor any other limbs. This we have ſhewn in the preſence of the celebrated Mr. Thevenot, a gentleman whoſe unuſual ſagacity, in every branch of polite learning, is above praiſe. We had the good fortune of changing before him the Worm of a Bee into a Nymph, by breaking the ſkin upon its head, upon which all the parts hid under it made their appearance; and we ſince have had equal ſucceſs in demonſtrating to the ſame gentleman, and the illuſtrious Lawrence Magellotti, a curious ſearcher into the ſecrets of nature, all the parts of the Butterfly clearly and diſtinctly in the original Caterpillar. We have ſince diſcovered alſo a method of changing, at pleaſure, the Caterpillar into a Chryſalis.

To comprehend in a few words the reaſons, foundation, and manner of theſe natural changes, and at the ſame time to illuſtrate them by a palpable ſimilitude, I need only briefly remark, that "the Nymph or Chryſalis" (I here ſpeak only of inſects without legs, the change that happens in the reſt, being, as will hereafter appear, ſo eaſily underſtood as to require no explication) "is nothing more than a little "Worm, which, the growth of legs, wings, "and other limbs hid under its ſkin being "perfected by time, at laſt burſts that ſkin, "and caſting it off, gives us a clear and diſ"tinct view of all thoſe parts." This change, which has been prepoſterouſly called a transformation, or metamorphoſis, and by ſome a death and reſurrection, is no more myſterious or ſurpriſing, than what happens, when "one "of the meaneſt plants, deſpiſed and trodden "under foot, gradually ſwells on every ſide; "and after producing a bud, by burſting the "little caſe containing it, preſents an elegant "and beautiful flower."

We might likewiſe compare, in this place, the ſanguiferous animals with inſects; as in reſpect to the accretion of their limbs there is not the leaſt difference to be found between theſe large creatures, and the little worm we have compared with vegetable ſubſtances: but amongſt all the animals of that tribe, none agree ſo exactly or obviouſly in theſe changes with the inſect tribe, as Frogs. Theſe creatures are changed into a true Nymph, known by the name of a Tadpole; as will more fully appear hereafter, in the explanation of our plates, and in comparing together the Tadpole, the Nymphs of Worms, and the little caſe in which flowers are produced, Tab. XLVI.

The ſame changes therefore, which we obſerve in vegetative animals, are equally obſervable in ſenſitive ones, ſo as to afford us in all God's works the moſt manifeſt proofs of his infinite wiſdom and power, which man can neither imitate nor comprehend: for as the foundations of all created beings are few and ſimple, ſo the agreement between them is moſt ſurpriſingly regular and harmonious, every thing conſpiring equally to fill us with ſentiments of admiration and reverence for the great Author of nature.

The ſerious conſideration of the preceding truths, will ſet in a juſt light the great error of thoſe, who, from theſe natural and intelligible changes in bodies, have endeavoured to explain the reſurrection of the dead; whereas that great operation not only far ſurpaſſes the powers which we ſee in nature, but has not any thing in common with the natural changes of which we have been ſpeaking: the reſurrection is a ſubject of faith only, which gives a certain and undoubted knowledge of things beyond the reach of our ſenſes. Theſe animalcules do not die, as man does, in order to riſe again; all that happens to them is, that their limbs become improveable at the time of their tranſmutation, which, however, happens in ſo ſurpriſing a manner, that it is no wonder obſervers, at firſt ſight, ſhould take the production to be a real reſurrection from a dead animal. This is all that can be offered from what we know of inſects, in proof of the reſurrection of the dead; which is altogether another thing, than that idle and imaginary death of thoſe animalcules, or the transformation, as it is called, of their limbs. Nor are thoſe authors leſs miſtaken, who, from theſe natural changes, which they idly call metamorphoſes, have endeavoured to aſcertain the transformation of metals; as amongſt others, the moſt learned Sir Theodore Mayerne has not feared to advance this abſurd notion in the dedicatory epiſtle prefixed to Mouffet's treatiſe on inſects. His words are: "Moreover, if "animals are tranſmuted, why may not metals be tranſmutable?"

To finiſh this inquiry, as it is much more eaſy to comprehend the change of the ſix-legged Worms, than that of the Worms without legs, of which we have hitherto been ſpeaking; ſeeing the former only acquire wings, Tab. XLV. fig. XXIV, XXV. and its limbs are ſeen to ſhoot or bud out, in the ſame clear, diſtinct, and gradual manner with the correſponding parts of plants and flowers, ſo as to agree more perfectly with ſuch vegetation, and with the change ſpoken of in Frogs; than what happens in the Worm without legs; ſo it cannot but appear ſurpriſing, that men of the greateſt ſenſe, learning and experience, who have at all times been indefatigable in obſerving theſe changes, ſhould have ſo long continued under a miſtake, in regard to the true manner in which they are performed; ſubſtituting all along, to a ſimple but elegant ſcene of wonders, the wild flights of their unnatural fancies. Hence it is, that the doctrine of inſects remains to this day buried in the profoundeſt obſcurity, ſo as that not only thoſe look upon it as a myſtery, who have few opportunities of being acquainted with ſuch ſubjects, but even thoſe alſo who have made this ſtudy their regular employment, and were the beſt qualified to purſue it with ſucceſs, ſuch as Aldrovandus, Mouffet, Libavius, and Goedaert; indeed, I might ſay all who have hitherto applied themſelves this way, have been ſo far deceived as not only to doubt and waver in their opinions; but influenced by prejudices obſtinately to remain inſenſible to the ſtrongeſt conviction, that the moſt obvious and convincing experiments could afford.

CHAP. III.

The manner in which the true knowledge of the Nymph, the real foundation of all the natural changes obſervable in inſects, has been obſcured and corrupted; with an illuſtration of the ſubject, and an entire reſtitution of its original truth.

HAVING manifeſtly proved in the preceding pages, that the Nymph, or Chryſalis, is nothing but the very inſect which may one day be expected from it; and having proved beyond contradiction, that the former lies hid within the worm, or its skin, in the ſame manner as the tender and growing flower is wrapped up in its bud; ſo that as the flower breaks from the ſurrounding cup, the limbs of the encloſed inſect, by the power which ſwells and ſhoots them forth, muſt, in the ſame manner, at laſt burſt their priſon, and make their appearance, which appearance alone conſtitutes the nature of the Nymph, or the knowledge of the foundation upon which all thoſe natural mutations depend. All theſe things, I ſay, having been abundantly demonſtrated, I can have no pleaſure in giving a long and pompous catalogue of thoſe authors, who have entertained different opinions of the matter, nor in refuting thoſe ſtrange fancies with which they have obſcured and perplexed this moſt valuable branch of natural hiſtory. Beſides, what purpoſe could ſuch a diſcuſſion ſerve, but to lead us ſtill further from the concluſion of this our ſecond propoſition, ſince the ſimple explanation of truth, is the beſt method of oppoſing and overturning falſhood?

However, as Mouffet's elaborate performance on this ſubject, is in a manner univerſally read by thoſe who ſtudy the nature and the changes of inſects, and is not only founded on the experiments of the author himſelf, and of his learned friends Wotton, Geſner, and Penn; but in part extracted alſo from upwards of forty authors, of which the learned Aldrovandus is one; and as the author follows ſo ſcrupulouſly the rules laid down by Ariſtotle, that he ſcarce ever deviates from them, it is incumbent upon us to mention what he propoſes in his elaborate treatiſe, where he lays down the changes that occur in the Silkworm, as an example of thoſe which happen in all other inſects; and gives ſuch an account of thoſe changes, as neither reaſon nor experiment can warrant. His words are theſe: * "It is very remarkable that in this metamorphoſis which is performed by means of an Aurelia, the Silkworm's head becomes the Butterfly's tail; and the head of this laſt the tail of the former; and the ſame thing happens in all the other Caterpillars that become Aureliæ." In another part of the ſame † performance, where he treats purpoſely of the Chryſalis, he ſays as follows: "It has neither a mouth, nor any diſtinct limb." Now as all theſe notions are directly oppoſite to the clear and diſtinct obſervations we have made, and already delivered, it would be ſpending time to little purpoſe to dwell any longer upon them; they have been already ſufficiently refuted. We need not be now ſurpriſed that this learned Engliſhman, who could be guilty of ſo great an error (which ſome eminent countrymen of his own have before taken notice of in a performance called, "A catalogue of the plants that grow in the neighbourhood of Cambridge,") ſhould not have taken the leaſt notice of the manner in which ſuch fanciful changes are performed, though in the ſame chapter he with great reaſon affirms, contrary to Ariſtotle's opinion, that the Chryſalis is not the egg of the Caterpillar. His words are : " To conclude, what is there here in common between an egg and an Aurelia ? The former has neither life nor motion, and is diſcharged from another animal ; the latter is not diſcharged by any animal, but is only changed from one thing into another." However, though Mouffet denies that the Aurelia is an egg, he has not courage enough to call it an animal ; he conſiders it only as a kind of medium, or mean condition, between two animals ; or as a third being between the Caterpillar and the Butterfly ; ſaying, " It appears nevertheleſs by what I have already ſaid, that the Aurelia is not an egg ; the truth is, that it is to be called a kind of tranſmutation, and not a generation of the Caterpillar into an Aurelia, and of the aurelia into a Butterfly." But as this difficulty, contrived by his own imagination, has rendered utterly inexplicable what otherwiſe might be very eaſily explained, he has recourſe, as is uſual in ſuch caſes, to the immenſe power of the Creator, and after this concludes the ſubject in the following words : " I well know how the Ariſtotlians perplex themſelves in this caſe with a wonderful transformation, and at laſt are obliged to refer us to God's indeterminate power."

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* Inſ. The. Lib. II. C. 1.

† Inſ. The. Lib. II. C. 36.

But we leave to the wildneſs of their own genius, thoſe learned men, who raſhly affirm that the true notions of every thing that appear in inſects, as well as in other bodies, are to be found in the eminent writers of antiquity. Nature, that indulgent parent, exhibits, all that relates to them, to us, every ſummer, in the plaineſt and ſimpleſt manner ; nay, ſhe gives us an opportunity of demonſtrating thoſe her proceedings, and that in the moſt ſatisfactory manner, in the very depth of winter, by the help of the artificial heat of a ſtove, or any like continuance. Let us rather take a ſpecimen or two of the unworthy manner, by which the genuine repreſentations of theſe changes, which are no more than the natural ſhootings of the limbs, that at laſt thereby come to make their appearance, have been confounded and obſcured, even by men who have ſpent their whole lives in reſearches into the nature of animal generation in general ; and have applied themſelves more particularly to find out the nature of thoſe changes obſervable in inſects.

The firſt I ſhall mention, is that ſecond Democritus, the celebrated Harvey, who, againſt the current of the moſt convincing experiments, boldly affirms with Ariſtotle, that the Chryſalis (though it be indeed the very inſect) is a perfect egg, from which of courſe the inſect may, by the help of transformation, be afterwards expected to ſpring. Take his own words : * " Such are likewiſe the ſeeds of many inſects, (called worms by Ariſtotle) which being at firſt produced in an imperfect ſtate, ſearch out their food ; by which being nouriſhed and increaſed, from a Caterpillar they become an Aurelia, and a perfect egg and ſeed from an imperfect one." By this, he not only with Ariſtotle calls the Chryſalis a perfect egg, which, according to the ſame author, is neither a Caterpillar nor a Butterfly, but ſeems to give into Mouffet's falſe and abſurd opinion, who affirms, that the Chryſalis is a kind of medium, or middle being between the Caterpillar and the Butterfly. This paſſage of Harvey's ſhews us, that he was not acquainted with thoſe inſects which proceed immediately from an egg in a ſtate of perfection, without ever appearing in the form of worms, Caterpillars, or Nymphs ; or at leaſt that he imagined the mutation they undergo is performed within the egg ; and that therefore their generation is the ſame in all reſpects with that which he has deſcribed as proper to Chickens within the egg of the Hen ; or with that other generation which he attributes to the worms of inſects †, which ſpring from eggs, and which he repreſents as perfectly agreeing with the generation of Chickens.

But although this great philoſopher calls the Chryſalis a perfect egg, he nevertheleſs does not aſſert that the inſect proceeds from the chryſalis, as from an internal and hidden principle, in the ſame manner that he affirms the chicken ſprings from the Hen's egg, or that the inſect is formed by one part of egg, while it only receives the matter of its increaſe from the other part ; which he ſays is the caſe in the generation of Chickens. Nay, his opinion on this occaſion is far more rational and ſolid, for he admits it, with Ariſtotle, as an axiom : ‡ " That the animal is not made out of the worm, as out of an egg, from a part of it ; but that the whole worm grows, and becomes an articulated animal," without conſidering that Ariſtotle calls the Aurelia an egg. Now if we compare the paſſage which Harvey has adopted from him, with the ſcene which nature every year preſents to us, we ſhall find the words contain a true definition of the Nymph : but as both Harvey § and Ariſtotle ** have here beſides fancied a metamorphoſis, which they call " a diſtribution of one thing that is to be altered into many ;" and which in another place †† Harvey has expreſſed by the following periphraſis : " In the generation that is performed by a metamorphoſis, things are produced as it were by the impreſſion of a ſeal, upon the matter of them, or by this matter's being caſt into a mould, the whole of it entirely transformed." This account is not only falſe, but altogether degrades and darkens the true ſyſtem of thoſe natural mutations : no ſatisfactory explication can be drawn from it, of any manner in which theſe fancied metamorphoſes, and imaginary transformations, can be ſaid to happen.

But the better to underſtand Harvey's doctrine of inſects, which, however, does not reach the outer limits of this branch of natural hiſtory; and at the ſame time, to ſhew what egregious miſtakes we are apt to commit, the moment we abandon the ſolid arguments furniſhed by experiments, to follow the falſe lights ſtruck out by our weak and imperfect reaſon, I ſhall here give his imaginary account of this matter, as I find it in his book upon this ſubject *, in his own terms,

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* Lib. de Gen. Anim. Exerc. II.

† Lib. de Gen. Anim. Exerc. LVII.

‡ Lib. de Gen. Anim. Exerc. XVIII.

§ Exerc. LXXII. de Hum. Primig.

** Lib. II. de Gen. Anim. C. 1.

†† Exerc. XIV. de Gen. Anim.

“There are two ways,” ſays he, “in which we obſerve one thing to be made out of another (as out of matter) both in art and in nature, eſpecially in the generation of animals; one is, when a thing is made out of another, already in being, as a bed out of wood, and a ſtatue out of ſtone; when, for example, all the ſubject-matter of the workmanſhip exiſts, before the workman begins the work, or attempts to give it any form. The other way is, when the ſtuff receives both being and form at the ſame time. As therefore the works of art are performed two ways; the one by the workman's dividing, cutting and paring away the matter prepared for thoſe operations, ſo as to leave behind, like a ſtatuary, the figure of the thing he intends to make: the other, by the workman's adding and moulding, as well as paring away, the materials, and at the ſame time tempering the matter itſelf, ſo as to produce. like a potter, the figure; which, for this reaſon, may be ſaid to be made, rather than formed. In the ſame manner it happens in the generation of animals; ſome of which are formed and and transfigured out of matter already digeſted and encreaſed for this purpoſe, all the parts ſpringing out together diſtinctly, by a kind of metamorphoſis; and thus forming a perfect animal, while other animals are made piece by piece, at firſt deficient both as to ſize and ſhape, afterwards receive both by degrees, from the ſame matter out of which they were originally formed. In theſe laſt animals, one part is made firſt, and the other parts, by means of this firſt, as the principle of the animal's exiſtence. This proceſs of nature, we call an epigeneſis, or accretion of parts, on account of her forming the parts gradually one after another; and this is more properly called generation than the other.

“The generation of inſects is performed after the firſt manner:” when the worm, by a metamorphoſis, proceeds from the egg; or the rudiments are formed out of matter in a ſtate of putrefaction (by growing too dry or too moiſt) “and theſe rudiments produce, as by a metamorphoſis, a Caterpillar grown to its full ſize, or an Aurelia, a Butterfly or a common Fly of its full ſize, ſo as never to grow bigger. But the more perfect ſanguiferous animals are formed by an epigeneſis, or a ſuperaddition of parts; and after their birth, grow to a ſtate of adoleſcence, and arrive at their perfection. Chance or fortune ſeems chiefly to pride in the production of thoſe animals, which owe their form to the power of a pre-exiſtent matter; which matter is the firſt cauſe of their generation, rather than any external efficient; for which reaſon thoſe animals are more imperfect, and perpetuate themſelves leſs, both as to number and likeneſs, than ſanguiferous land or water animals; which, by deriving their being from an univocal principle, (that is, from other animals of the ſame kind) keep up an eternal ſucceſſion; and the cauſe of of this we attribute to nature, and a vegitative power.

“Some animals, therefore, are produced of themſelves from matter digeſted ſpontaneouſly, or by mere chance, as Ariſtotle ſeems to advance in the VIIth book of his metaphyſicks, chap. 9. Thoſe animals, to wit, whoſe original matter can give itſelf motion, ſuch a motion, by accident, as the ſeed gives itſelf in the generation of other animals. And the ſame thing happens in the generation of animals, that is obſervable in the works of art; for ſome things which are produced by art, are likewiſe brought about by accident, as health; other things that are made by art, are never made otherwiſe, as a houſe.

“Bees, Waſps, Hornets, or Butterflies, and whatever other animals are generated by metamorphoſis from a creeping inſect, are ſaid to be the offſpring of chance, and therefore never to keep up their ſpecies. But the Lion or Cock are never produced ſpontaneouſly or by chance, but are the work of nature; wherefore they do not require a ſuitable matter, or ſome other divine power, ſo much as a ſimilar form.

“In the generation by metamorphoſis, animals are faſhioned as it were by the impreſſion of a ſeal, or framed in a curious mould, all the matter of which they conſiſt being transformed; whereas the animal which is produced by way of epigeneſis, or accretion, at once attracts, prepares, digeſts, and makes uſe of the ready matter; it at once grows and acquires its form. In the former, the plaſtic power divides the ſame ſimilar matter, arranges it when divided, and reduces it into limbs; from ſimilar making it diſſimilar, or forming diſſimilar organs with a ſimilar ſubſtance. But in the latter, whilſt it produces in order different parts, and thoſe parts differently diſpoſed, it requires and makes different ſubſtances; and ſubſtances are variouſly diſpoſed, the better to ſuit the different parts that are to be generated.”

This is the doctrine of Harvey; and this his diſſertation contains almoſt as many errors as words. This may appear ſurpriſing in one ſo well verſed in enquiries of this kind, where truth can only be aſcertained by experiment: notwithſtanding all his errors, we muſt do his great merit in other reſpects juſtice; his diligence in ſtudying nature was very great, and

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* Lib. de Gen. An. Exerc. XLV.

he therefore deſerves not only our praiſes, but thoſe of all mankind; and the candid manner in which he uſually offers his opinions, is yet more praiſe-worthy; for he thus moſt ingenuouſly ſpeaks, in the preface to that performance I have been juſt now mentioning: "Therefore, (generous reader) I do not expect you ſhould take my word as to the manner in which the generation of animals is performed: I appeal to your own eyes as witneſſes and judges of what I advance. For as all perfect ſcience is built upon ſuch principles, as are derived from the obſervations of ſenſe; you ought ſtrenuouſly to endeavour, if you have a mind to become thoroughly acquainted with what relates to animals, to attain this knowledge, by frequent diſſections of them. If you proceed otherwiſe, you can only acquire a ſpecious and wavering opinion, but no certain and ſolid ſcience."

To conclude, it is not our intention to refute one by one, in this place, all this ingenious but miſtaken author's propoſitions; ſeeing this is abundantly done already, by the evident truths we have produced; neither will the dignity of ſo great a name, eaſily admit of ſuch a cenſure, (in abſtaining from which, we only follow the example himſelf has given us in the caſe of that famous anatomiſt Fabricius ab Aquapendento, whom he ſpares in the ſame manner, and on the ſame account.) Nevertheleſs, I cannot avoid again inculcating at leaſt one principle; that whereas the Nymph is indeed the animal itſelf, and by no means the egg, the whole and only mutation which happens here, is nothing more than a ſlow evaporation of the ſuperfluous moiſture; for by this all Nymphs are neceſſarily changed.

Thus it happens, that during this evaporation, before explained in the Nymph of the Bee, the limbs which were before tender, weak, and fluid like water, are freed from the ſuperfluous moiſture which deprived them of motion; whereby the latent inſect is enabled to force its exterior covering, and, having caſt it off as the Bee does, or forſaken it as is done by the Butterfly, to make uſe of the moiſture which remains, to expand its wings and other parts.

The Nymph therefore, during the firſt days of its change, reſembles a man who has loſt the uſe of his limbs, by a collection of ſaline or other humours about his joints, and does not recover them, till ſuch hurtful moiſture is diſſipated by nature, or by art. Nature and art have the ſame effect upon tumified members, and upon what we call Nymphs; ſo that on evaporating the ſuperfluous humidity of theſe laſt, by the means of nature, or by an artificial heat, they may be brought forth in the form of inſects, even in the depth of winter.

In fine, as it is utterly erroneous to ſuppoſe, that the whole maſs of the Worm is transformed into the Nymph, and after this the Nymph into a winged land or water animal; ſo, on the other hand, nothing is more certain, than that all the limbs of the Butterfly, the common Fly, and ſuch other inſects, do actually grow in the Worm, in the ſame manner as the limbs of other animals: ſo that nothing can be more repugnant to truth, or be ſo little ſupportable by any ſolid arguments, as this notion of a metamorphoſis: for it is not in the Nymph alone, but in the very Worm, or Caterpillar: Tab. XXXVII. fig. II. III. and IV. we can lay before the eye all the parts of the future inſect. Thoſe parts are by no means generated ſuddenly and all at once, as has been ſuppoſed; but grow leiſurely one after another, till all of them having arrived at a ſtate of perfection, the Worm gives itſelf motion, and breaks its ſkin; the incloſed limbs having generated by degrees, from the motion of the moiſture, and their own contraction, ſwell and eaſily caſts its ſkin, and ſuddenly diſcloſes all its limbs to our view. In this inflation, (ſhooting out, budding, or vegetation; and, as it were, changing of the nutriment of the new limbs, which have gradually grown, or have been produced by an epigeneſis, or accretion of the parts, and not at all by a metamorphoſis) conſiſts the ſole foundation of all the changes which we remark in inſects. We call the creature in the ſtate of this natural mutation a Nymph, becauſe this kind of inſect, on caſting its skin, may be ſaid to reſemble a bride or Nymph, who, in many countries, leiſurely prepares and adorns her perſon for her intended ſpouſe. But we utterly deny what Goedaert has in ſeveral places advanced, that there is any reſemblance between the Nymph and an infant in its ſwathing clothes; as alſo its likeneſs to any other figure than that of the future inſect; for the Nymph not only repreſents clearly and diſtinctly all the parts of the future inſect, but is, in reality, the inſect itſelf; and this, not dead or buried, but, as Libavius has already obſerved of the Necydalis, actually living and feeling, though unable to give any indications of life, except by the motion of its tail or belly; for in many we find theſe parts are not affected with any moiſture, nor undergo any change, but what ariſes from the caſting off a very thin skin, ſo that they cannot loſe their former power to move.

Allowing therefore as a certain truth, as it really is, what has been already advanced in this work concerning inſects, not only all that Harvey ſays upon the ſame ſubject, in the extracts we have given, and all the errors that flow from thence, fall to the ground; but likewiſe that common opinion of philoſophers, that the generation of inſects is fortuitous, and which Goedaert's editors ſeem to have fathered, or rather to have forced upon him, appears utterly groundleſs; ſeeing it has no other foundation, than that idle and imaginary metamorphoſis, which neither exiſts in nature, nor can fairly be deduced from Harvey's (in many places) contradictory arguments. This great man muſt have eaſily ſeen the weakneſs of his own repugnant notions, had he not been too much prejudiced in favour of the opinions which they were calculated to ſupport or explain, if the reſpect we owe him will, after all, permit us to think he really gave into this abſurd notion. Perhaps we may with more juſtice aſſure ourſelves, that he proceeded on this occaſion, in the manner that people generally proceed in conſidering things that are difficult to be underſtood and accounted for; that is, by fancying ſomething, which ſeems, on mature deliberation, beſt to agree with the nature of things, as Ariſtotle had long ſince directed, in his treating of the generation of Bees [*]; his words are, “That the generation of Bees is performed in this manner, ſeems not only agreeable to reaſon, but to what appears to happen in the generation of other inſects of this kind; however, the obſervations hitherto made are not ſufficient to give us a certain knowledge of what it is that really happens. When we have acquired that certain knowledge, we muſt truſt our ſenſes, rather than our reaſon, by which we are to be guided, as far only as what it demonſtrates, agrees with what our ſenſes aſcertain.” Daily experience ſhews us, how many and how great errors this method of philoſophiſing hath produced; ſo that an author would do much better to own his ignorance ingenuouſly, than to lead aſtray, by unnatural phantoms, thoſe multitudes of credulous readers, who, idly thinking that all true learning is to be found in books, never give themſelves the trouble of immediately conſulting nature herſelf: perhaps we ought rather to pronounce ſuch idle followers of knowledge well worthy of this puniſhment, for neglecting the opportunities of finding it in the things themſelves with which they are deſirous to be acquainted.

Having ſhewn in ſome meaſure on how uncertain a foundation Harvey's account of the natural mutations of inſects is erected, it remains to conſider with what groſs errors, and palpable falſhoods, Goedaert has defiled them: but at the ſame time we own with ſatisfaction, that this author alone obſerved and diſcovered, in the ſpace of a very few years, more ſingularities in the Caterpillar kind, than had been done by all the learned men who treated the ſame ſubject before him. Notwithſtanding this, we cannot help ſaying, that not only he was not free from miſtakes, but that he has made ſome ſuch important ones, as can ſcarcely, if at all, be excuſed: not to mention his not having had the leaſt notion of the true nature of the Nymph. But as we have reſolved to examine on a ſucceeding occaſion, ſeparately, all the errors of this author, we ſhall produce at preſent only two of the moſt glaring; upon which, as upon a frail and ſlippery foundation of ice, all his experiments are built. Nor ſhall we do this with any other view than that of making truth appear the more ſtrong and plain, by being compared with falſhood; for the more naked truth is propoſed, the more powerful it is to ſubdue errors.

In the firſt place Goedaert is under a very great miſtake, when he advances, that the Caterpillar can be changed, before it has reached the full term of its growth; adding alſo, what is ſtill more apt to lead people aſtray, that the mutation effected in this manner is very incomplete and unnatural. But let us attend to his own words, in the firſt volume of his ſingular obſervations on the wonderful mutations that happen in the Caterpillars, page 12 of the Dutch edition. “I have beſides obſerved,” ſays he, “that, whenever the Caterpillars effect a mutation, before they have been ſufficiently fed for that purpoſe, and have reached the full term of their growth, they never receive a perfect form in conſequence of ſuch premature change, but are miſhapen and miſerable, with ſhort and ſhrivelled wings, like a piece of ſcorched parchment; whereas otherwiſe, in leſs than half an hour, theſe uſeful parts expand themſelves, and acquire their proper beauty, with a variety of elegant colours. Hence it happens, that the unhappy inſect, not being able to make any uſe of thoſe imperfect wings, is much more miſerable than it was before its change, being obliged to creep upon the ground, where it at laſt periſhes for want of proper nouriſhment.” Afterwards, in his twenty-eighth experiment, it appears, that on the ſtrength of the foregoing hypotheſis, having for ſeveral days ſupplied a Caterpillar with food, though all the time preparing for its mutation, be breaks out into the following words: “If I omitted giving it food, but for one day, it immediately ſet about changing; for which reaſon I took care not to make it faſt any longer, as ſo premature a change was likely to produce but an imperfect Butterfly; for it is remarkable of all Caterpillars in general, that as ſoon as they find their food fail, they prepare for a mutation; but if it fails of its food before the term appointed by nature, the inſect produced is both imperfect and tender; ſo that to have a ſucceſſion of complete Butterflies, the Caterpillars muſt be provided with food, till they refuſe it of their own accord, in order to enter upon the buſineſs of mutation.” At length, after having given in the eighth experiment on the ſtrength of a mere conjecture, the example of a nocturnal Butterfly, which was, in his judgment, the weaker, becauſe its Caterpillar had been deprived ſooner than it ought of its ordinary food; in the fifty-ninth experiment of the firſt volume, and afterwards in the thirtieth of the ſecond, he in a manner opens the ſource from which he derived all thoſe his miſtakes; for after deſcribing a very miſerable animal, that was neither a Caterpillar nor a Butterfly, according to the idea he had idly formed of it in his own fancy, he adds, “The reaſon of all this is, that the Caterpillar had entered upon the buſineſs

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[*] Gen. Anim. Lib. III. C. 10.

" of mutation, before it had taken its proper " quantity of nouriſhment." As this argument appeared to him moſt inconteſtible and evident, he afterwards, in the twenty-ninth and thirtieth experiments of his ſecond volume, where he deſcribes ſuch another imperfect animal, and one with wings, does not mention one word of this falſe propoſition, but paſſes it over in ſilence, as if ſufficiently proved, and not liable to contradiction.

Since in the places here cited two animals are exhibited, one of which, namely, the female, is always, by an invariable law of nature, tranſmuted without wings, Tab. XXXIII. fig. VI. whilſt the other, which is the male, never appears without them. No. VI. not only the genuine foundation of all natural mutations is overturned, and rendered obnoxious to chance, by the idle comments which we have extracted from Goedaert, but the road to truth is alſo rendered impracticable, at leaſt to the unſkilful.

Goedaert himſelf could not avoid the conſequences of ſuch raſh and idle fictions; he has thence fallen into two other miſtakes. The firſt is ſeen in the pains he muſt have been at to ſupply his Caterpillars with food as long as they required it. The ſecond, his omitting, on this account, ſome very curious experiments; for, infatuated with his own prejudices, he neglected the true knowledge he might have acquired by his experiments, to adopt a falſe reaſoning; ſo that he could never afterwards by his experiments come to know, that the ſpecies of Caterpillars he deſcribes, are never changed after any other manner; the male Caterpillar becoming conſtantly a tender inſect, furniſhed with wings, and the female a coarſe and big-bellied one without any.

The obſervation made in the place here cited appears to be of the utmoſt importance, viz. " That the male of the nocturnal Butterfly is " is always provided with wings, whereas the " female never has any;" ſo that the male can enjoy the ſweet refreſhments which the free air affords, and ramble at pleaſure over the ſmiling fields and fragrant flowers, when, on the other hand, the care at home, and management of the fruits of wedlock, are committed to the female only; for which reaſon, ſhe is always found with the hinder part of her body thruſt out, in order, as it were, to induce the male to do his duty; nor does the male ſeem indiſpoſed to perpetuate his ſpecies. Nature, therefore, intended to afford us in theſe inſects the moſt ſtriking examples of an affectionate mother, and a careful father; and perhaps, as the ſlothful were formerly refered to the ant, as a pattern of induſtry, married people, that neglect the duties of their ſtate, may, with equal propriety, be deſired to conſider this other little inſect as a model of conjugal ſolicitude.

As it ſufficiently appears from our experiments, which contradict thoſe of Goedaert, (though that very obſervant author has taken the right method in making them, and hath given tolerably accurate figures) what falſe conſequences he has deduced from thence, and, by that means, rendered the ſtrongeſt baſis of the origin of inſects wholly ſubject to chance; we ſhall now reſtore this foundation, whereon, as on a rock, depends the whole fabrick of the tranſmutations of inſects, and ſhall lay down the following as undoubted axioms. Firſt, that the Caterpillar cannot be changed before the time appointed by nature, that is, the laſt moment of its growth. Secondly, that although Caterpillars may be transformed before they leave off feeding, yet this has no effect to cauſe any change in their form. We muſt however acknowledge that ſome difference in ſize may ariſe from hence, which we muſt obſerve hath not been noticed by Goedaert, nor, hitherto, by any other perſon. Wherefore, thirdly, we by no means think it neceſſary that the Caterpillar ſhould be fed until it ceaſes to eat of its own accord; for at the time when it is to undergo a change, the buſineſs of feeding is not only unneceſſary and difficult, but entirely uſeleſs. Conſequently, the concluſions of Goedaert before mentioned, have not been drawn from the nature of things, but from his own falſe and chimerical notions. For he, not having examined his experiments with deliberation and diligence, deceived himſelf and others.

We may take it for granted, that as ſoon as the Caterpillars have arrived at their utmoſt growth, that is, when all the limbs under the ſkin have grown to a proper ſize, they have not only power and ability, but alſo, if I may be allowed the expreſſion, a free and abſolute will to begin their mutation, with this reſtriction only, that they cannot omit or avoid it; ſince the budding limbs, which demand, as it were, to be changed into the Nymph, in proceſs of time, burſts the ſkin, though they can feed for a conſiderable time afterwards: but then, as I have before obſerved, this further feeding is of no other uſe but to make the creature larger or ſmaller, for from that time not even the leaſt of their limbs is increaſed in length. This Harvey hath alſo remarked, in his treatiſe of the generation of animals. From hence it alſo follows, that theſe animalcules, now grown to perfection, attaining the age of maturity, and fit for the copulative ſtate, apply themſelves ſolely to propagating their ſpecies, in the execution whereof ſome particulars are ſo aſtoniſhing, that they deſerve everlaſting admiration.

Nature performs the whole proceſs of generation in theſe inſects in ſo clear and open a manner, that by the aſſiſtance thereof it ſhould ſeem as if we could penetrate into the true foundations (though hitherto buried in darkneſs) of the generation of other animals, which we ſhall evidently demonſtrate, when we have time and opportunity for further experiments.

That we may give our opinion on this head in a few words, it ſeems very probable, that in the whole nature of things there is no generation that can be properly ſo called, nor can any thing elſe be obſerved in this proceſs, than the continuation, as it were, of the generation already performed, or an increaſe of, or addition to, the limbs, which totally excludes the doctrine of fortuitous propagation. Having eſtabliſhed this principle, it is eaſy to explain the reaſon that a man, deprived of hands and feet, may have a ſound and perfect offspring. Hence, alſo, we may determine that famous queſtion, whether, in order to produce a complete iſſue, a ſeminal particle drawn from every member of the body be abſolutely neceſſary. Moreover, the reaſon is evident, how Levi, being yet in his father's loins, paid tythes long before he was born: for he was in his father's loins, when Melchiſedeck met Abraham. Laſtly, even original ſin (in the opinion of a very learned man, to whom we have occaſionally communicated the myſteries of our experiments) may ſtand on this principle as on a firm foundation, ſince all mankind have been laid up originally in the loins of their firſt parents. But, ſince others claim the right of explaining ſuch myſteries, we ſhall enter no further into this matter, but come to another error of Goedaert, intending to diſcuſs the reſt, when we have occaſion to examine any more of his experiments; for it is not our intention to build on another's foundation.

A further error of Goedaert appears in the 77th experiment of the firſt part, in the words following: " What is more particularly wor-
" thy of our notice in theſe inſects is, that
" wherever the legs are ſituated in the Cater-
" pillar, there is placed the back of the ani-
" malcule that is to ariſe by tranſmutation:
" and on the contrary, where the back of the
" Caterpillar was, there, are the legs in the
" animalcule to be produced from thence.
" This metamorphoſis, adds he, (which ren-
" ders him the more blameable) is per-
" formed in a ſhort ſpace of time, ſo that it
" may be diſtinctly ſeen; becauſe immediately
" after ſhedding its ſkin, this change appears
" to the eye." From hence may ariſe a proper opportunity of explaining accurately and carefully the true tranſmutation of the Caterpillar into the Chryſalis; but as this matter is (as far as hitherto is neceſſary to be explained) very evident, from what we have on ſeveral preceeding occaſions ſaid thereon, we ſhall here paſs it over in ſilence; and the rather, becauſe we have determined to treat this matter profeſſedly in the following ſheets; for we ſhall ſhew from reaſon, and illuſtrate by figures, after what manner, and in what place, every limb of the Nymph and Butterfly are diſpoſed and arranged, which we have before actually laid before the eye, in the preſence of Magalloti and Thevenot, by ſhewing all the limbs of the Butterfly in the Caterpillar. Therefore, to prove the falſity of what we have cited out of Goedaert, it is ſufficient only to repeat, that the ſix fore legs of the Caterpillar are never changed or tranſpoſed in any remarkable manner. And though Goedaert thought himſelf ſuperior, with reſpect to the ſharpneſs of his ſight, to Mouffet, Harvey, and others (whoſe thoughts on this ſubject were conjectural) and has aſſerted the contrary to their doctrine, yet nothing is more certain than that not only he, but thoſe who boaſt to have ſeen it, were groſsly deceived. This deception may poſſibly ariſe from two cauſes: the firſt is the ſwift ſhedding of the ſkin; whence it happens, that the limbs, hitherto hidden, ſuddenly appear, and are diſpoſed in a form quite different from what they were in the Worm: the ſecond may be owing to ſome protuberances and ſwellings, which are on the back of the Caterpillar, and, as ſoon as the ſkin is ſhed, have the reſemblance of legs. Indeed, a perſon more quickſighted than Goedaert, may be deceived by this, ſince the change of the ſkin happens ſuddenly, and, as it were in the twinkling of an eye: wherefore, even the more modern authors, who wrote moſt accurately on this ſubject, have diſcovered nothing elſe, than that the ſkin is firſt broken on the head and back. This is plain from that very elaborate treatiſe of the generation of theſe inſects, publiſhed by Francis Redus, principal phyſician to the grand duke of Tuſcany, in his own language, in the year 1668; wherein he has proved, by the ſtrongeſt arguments, that no inſects are generated by putrefaction. This doctrine we ſhall not only willingly grant this eminent phyſician, but further we ſcruple not to aſſert, that putrefaction is, in a great meaſure, produced by thoſe very inſects which are ſuppoſed to ariſe from it: but of this matter more at large hereafter.

In order to ſhew the origin of thoſe ſwellings on the back of the Caterpillar which impoſed on Goedaert, as ſo many ſignals of changing their legs, it muſt be obſerved, that many of the Caterpillars, whilſt they are changing, caſt off from thoſe hairs wherewith their bodies were before roughened and briſtly, a very tender, and, as it were, membranous ſheath; after which, the finer part of thoſe hairs appear like ſo many linen threads in the Chryſalis. But ſince this Caterpillar of Goedaert's is covered with hairs which are more like briſtles than linen thread, it follows, thoſe hairs and the reſt of the body having ſhed their ſkin, form in the Chryſalis the figure before mentioned, and appeared as if the legs were tranſpoſed. This is what led Goedaert into another error: for if he had known theſe ſeveral particulars, he might have eaſily inveſtigated the origin of thoſe ſilken yellow threads, which he tells us he ſaw in the Chryſalis, and which are deſcribed in the 20th experiment of the firſt part.

It is not only very certain that the change of the Caterpillar into a Chryſalis may be perceived by the eye, but our experiments proceed ſo far, that, by following nature, we are able to produce the Chryſalis from the Caterpillar ſtate. Nay, it is in our power to keep back this tranſmutation, or to retard the ſame to any degree we think proper, though it happens ſo ſwiftly and ſuddenly, and therefore, undoubted credit ought to be given to the ſeveral matters we publiſh here concerning this change. Hence it is, that we can now exhibit to public view many Chryſallides, reduced to almoſt one half; this, among ſeveral other myſteries of nature, we have ſhewn before his ſerene highneſs Coſmus the third, grand duke of Tuſcany, when he, by a ſpecial mark of diſtinction, was graciouſly pleaſed to viſit us, and to approve of our experiments.

But to have done with the errors of Goedaert, which we have hitherto been ſetting right, we ſhall lay down the following as undoubted truths. Firſt, that the legs of the Caterpillar, or Worm, are never tranſpoſed to the back. Secondly, that the Caterpillar is not changed into another animal, though, in proceſs of time, the legs themſelves grow in the ſame manner, as the wings of a young bird, or feet of a Tadpole. Thirdly, that no natural transformation happens in theſe inſects; but that this whole change, (in finding out the nature whereof, authors have committed ſo many errors, and proceeded, as it were, blind-fold, like the combatants of old) conſiſts only in this, that the limbs of the Caterpillar, or Worm, by an accretion of the parts, grow inſenſibly under its skin; and when the latter is ſhed, the former appear plainly and diſtinctly to the ſight, but they cannot be moved at firſt by the little animal; the reaſon of which is, becauſe they are fluid like water, and cannot acquire ſufficient ſtrength, unleſs they evaporate it for ſome days before.

But this does not hold in all Worms, ſince there are many which loſe no part of their motion. To render this matter the more clear, we ſhall now proceed to the third propoſition, deſiring the reader to conſider it attentively, as it is a matter of the greateſt importance, and of very great extent.

CHAP. IV.

Of the four orders of natural changes, to which we refer nearly all the ſpecies of inſects, as having the ſame ſole principle of change.

HAVING hitherto, from the nature of things, examined and drawn, as it were, a juſt and elegant picture of the true origin of theſe appearances, or, as they may be called, ſudden buddings and ſhootings into limbs in inſects, and by that means, ſhewn how this ſubject hath been diſgraced and obſcured by chimerical notions, and the idle traditions concerning theſe changes; having likewiſe cleared the ſubject from the impurities wherein it was involved, by eſtabliſhing it on a ſtrong and firm foundation, which cannot be ſhaken by any force; and in our opinion, can no more be ſet aſide in favour of fortuitous chance, than a Lamb can be generated by a Wolf, or an Eagle by a Dove, we ſhall now proceed to the poſitions themſelves, or to the ſeveral orders of theſe changes; whereby, as with the genuine tinct of nature, we ſhall endeavour to illuſtrate the picture before us, and reſtore the amazing and wonderful appearances of inſects to their true ſplendor and native beauty. Thus ſhall we more clearly be ſenſible of, and, with greater devotion and more humble reverence, meditate on the omnipotent wiſdom and ſuperlative goodneſs of God in the accretion, ſuſtenance, and change of the minuteſt animalcules, which form a celeſtial hoſt as the angels.

If we diligently attend to this true baſis of all the changes of inſects, that is the Nymph, it will be eaſy to comprehend the reaſon why all the ſpecies, tho' ſo many in number, together with their changes, agree and terminate in this one particular; wherefore it ſeems ſuperfluous to dwell longer on the explanation of them. If again we more ſeriouſly conſider after what various ways this Nymph hides itſelf under the manifold forms of thoſe inſects, ſo as to elude the ſharpeſt eye; it will become neceſſary to view this Nymph in every light, under all its accidental appearances. And herein we ſhall not follow as a guide the deluſive traces of our own ingenuity, or admit the inventions of fancy, but purſue only the various and natural phænomena of the Nymph. There are four orders which comprehend the whole claſs of inſects, ſo that we cannot ſee one, which may not be referred to one or other of them, eſpecially if we can ſee its change.

The firſt order will comprehend thoſe inſects, which, with all their limbs and parts, proceed inſtantly out of the egg, and grow inſenſibly, until they attain a proper ſize; after which they are changed into the Nymph, which undergoes no other change but that of its skin.

Of the ſecond order are thoſe hatched with ſix legs, and which, when the wings are gradually perfected, are alſo changed into Nymphs.

The third order is, when the Worm or Caterpillar comes forth from the egg either without any legs, or with ſix or more, and its limbs afterwards grow under the skin, in a manner imperceptible to our ſight, until at length it caſts that skin and reſembles the Nymph, or Chryſalis.

The fourth order is, when the Worm likewiſe proceed from the egg, either without any, or with ſix, or more legs, and in an inviſible manner grows in its limbs and parts under the ſkin, and does not ſhed this ſkin, but acquires the form of a Nymph under it.

Having laid down theſe general propoſitions, I ſhall hereafter diſtinctly and at large, deſcribe the Nymph under theſe four different orders; and at the ſame time ſhall lay it before the eye by particular examples, illuſtrating every deſcription; but in the firſt place, I ſhall enumerate the inſects which belong to each order.

The FIRST ORDER.

Of the natural changes, or ſlow accretion, of the limbs.

AS on the one hand it appears, from the niceſt experiments, that all inſects proceed from an egg, that is laid by an inſect of the ſame ſpecies, with whatever warmth ſome philoſophers have maintained the contrary; ſo on the other it muſt be obſerved, that ſome inſects iſſue therefrom inſtantaneouſly, and, as it is ſaid, perfect in all their parts, as almoſt all the kinds of Spiders, and many more. Others, on the contrary, undergo ſome changes before their parts are finiſhed, which is the property of a great number of Worms and Caterpillars; for when theſe inſects aſſume the form of a Nymph or Chryſalis, under this ſhape they ſuffer another change, or rather, the ſame evaporation of the ſuperfluous moiſture which the animalcule ſuffers in the egg when it iſſues from thence, or which they themſelves have alſo ſuffered in their egg, before they underwent this change,

Hence it is, that as ſome inſects come from the egg perfect in all their parts, Tab. I. fig. II. *a.* ſo, on the contrary, others are forced from thence imperfect as it were in their ſeveral limbs. But as the former often change their ſkin, though they be not afterwards transformed into Nymphs, which are diſcoverable by certain new limbs, before they grow mature, and are rendered fit for generation, ſo the latter ſometimes caſt their ſkins, and when they throw off the laſt, under which they acquire the form of a Nymph, and are furniſhed with new limbs, Tab. XVI. they likewiſe attain to maturity; after which neither the former nor the latter inſects caſt their ſkin or grow, but apply themſelves, with all their ſtrength, to the buſineſs of generation; and then, pleaſed as it were with their paſt employment, they die in peace, unleſs it be ſo ordered by nature, that they are obliged to feed their young, and for that purpoſe muſt neceſſarily live ſomewhat longer. Indeed, moſt inſects are found of ſuch a nature, as ſcarcely to live more than four hours after the time of their laſt change, and the buſineſs of generation is over: ſo that nature ſeems to exert her utmoſt ſtrength upon this occaſion, and the beginning of life in one little animal is the end of it in another, as we ſee every day in the motion of the weights affixed to clocks, one of which deſcends whilſt the other aſcends. But we ſhall treat more fully of theſe matters in their proper place.

To explain our obſervations on the egg ſomewhat more amply, and as far as may be proper in this place, we muſt add, that we have remarked, that the inſects which proceed inſtantaneouſly, or perfect, from the egg, as well as thoſe which iſſue from thence in the form of Worms, are diſpoſed and placed in the ſame egg as cloſe as can be, and without any food in their power, in the ſame manner as the Worm and Caterpillar lie ſtill and compoſed, without the leaſt food, when they have put on the form of a Nymph, as we have obſerved. This will be clearer when we come to the fourth order of tranſmutation.

Further, as the Worms and Caterpillars beforementioned, when changed into Nymphs, are fluid like water, and ſwoln on account of their limbs being extended by a ſuperfluous moiſture; and as they cannot move, although they live and breathe; ſo we have found, that our animalcules lying in their egg, and being alſo fluid like water, are incapable of the leaſt motion. Wherefore, as the inſect formed from the Nymph, or rather the inſects themſelves, hidden under the form of Nymphs, do not appear, till theſe redundant humours have been diſſipated, and their limbs have acquired ſufficient ſtrength to burſt the outward ſkin; ſo likewiſe theſe animalcules, which are protruded from the egg, either perfect or imperfect, do not part with theſe their eggs or coverings, before the ſuperfluous moiſture is expelled, and their feeble limbs have acquired ſufficient ſtrength, ſo as to be able to break through the outmoſt ſkin, wherein they are involved as in a ſhell, and to quit it, as ſoon as it is burſt or perforated.

If we attentively conſider what has been hitherto advanced, which is indeed of great moment, and productive of many uſeful concluſions, we ſhall be inclined to determine, that thoſe eggs, wherein the animalcules lie ſtill without food, in the figure of Nymphs, and which, for that reaſon, often have the form of the animalcules that are to proceed from them, ought not, properly ſpeaking, to be called eggs, but Nymphs in the form of eggs, or oviform Nymphs. The former inſect, for this reaſon, though yet in the egg, may not be improperly called a Nymph-animal oviform, or in the appearance of an egg; as the latter may be denominated an oviform Nymph-vermicle, or Worm-Nymph. Nay, the egg, as it is called, or rather, the coat wherein they are wrapped up, ought to have the appellation of their ſkin, rather than that of the ſhell or egg wherein they are to be generated or formed: but we have already touched upon theſe obſervations concerning the skin in the foregoing pages, when we treated of the Nymphs and Chryſallides caſting their skin.

As our intention is to offer ſome rules and orders of tranſmutation, which comprehend all the changes that happen in the inſects known to us; we ſhall fix our eyes firſt on the changes of thoſe inſects, which iſſue inſtantaneouſly, as it is ſaid, out of the egg, and which have already gone through the whole proceſs of their change, or accretion of their limbs in their mother's womb; that is, when by the continual increaſe of their inviſible yet eſſential parts, as they are called, they have become perfect animals in the egg, they have undergone no other change out of it, except only the evaporation before mentioned; nor are they to be afterwards ſubject to any other change or accretion into a Nymph, which is alſo performed only by evaporation.

This we ſhall offer as the firſt, ſimpleſt, and plaineſt method of change in inſects, and from this we ſhall proceed by degrees to ſuch as are more obſcure, complete, and difficult of comprehenſion, mentioning ſome ſo intricate, that, it ſeems to many, they cannot be explained at all. This notion hath been ſo eſtabliſhed by cuſtom, that for want of a more proper term, the bodies have been called eggs; ſince to a perſon, who views them ſlightly and ſuperficially, not even the leaſt veſtige of any diſtinct limb appears in them.

The firſt order of change then, according to our ſyſtem, is, when the inſect, lying in the egg or ſkin without food, after ſome days evaporation and diſſipation of the ſuperfluous moiſture, creeps out of it, perfect in all its parts, ſo that afterwards it is not changed into a Nymph, nor undergoes any other remarkable mutation. But ſince this inſect, before it hath arrived to its full bigneſs and proper growth, by means of the food that is given it, is ſometimes obliged to caſt its skin, like the Worms or Caterpillars that are changed into Nymphs; and ſince, under the laſt change of the skin, its limbs alſo undergo ſome tranſmutation; it is therefore the inſect ought to be conſidered as a real Nymph, at the time it is in its laſt skin; for when this is caſt, it is obſerved to be fit for generation, and to have come to its maturity and full vigour, and not before.

Since therefore ſome inſects are changed after they have caſt the laſt skin, which may be exemplified in the long-legg'd Spider deſcribed by Goedaert; we ſhall, for this reaſon, conſider this inſect as a kind of Nymph, and for diſtinction ſake call it a Nymph-animal. Not that we would have any perſon tied down to make uſe of the terms we have offered, being ſatisfied, if the orders of theſe changes be as diligently, accurately and diſtinctly obſerved as they are in nature, for in this lies the principal and only knowledge.

If we further ſeriouſly attend to this change, we ſhall plainly ſee, that it not only agrees with the accretion of the limbs in ſanguiferous animals, but alſo with that epigeneſis, or ſuperaddition, obſervable in plants or vegetables; this therefore we would have underſtood of the orders of changes, and ſhall accordingly make the like application.

To give ſome inſtances of what happens in ſanguiferous animals, none ſeems more proper for that purpoſe, than the accretion of the limbs in a Frog, Tab. XLVI. *a.* for as the young Frog is very viſible, by means of the black ſpot which we ſee in the egg, ſo we find that this is nothing but the very animal, in the ſame manner as we have ſhewn in inſects. But as the inſects are not produced with their food, ſo no other difference can be diſcovered in this caſe, than that the young Frog iſſues forth with its proper aliment; and it is alſo found to be wrapt up in a certain membrane like the inſect, though it ſtill feeds for five days within it.

Further, as the Frog, immediately after the burſting of this membrane, finds matter to feed upon, for it lies in the midſt of it, ſo likewiſe are the inſects readily ſupplied with nouriſhment, when their eggs are broken; ſince ſome of them are placed within, and the reſt without, and upon the ſubſtance on which they are to feed.

To purſue the analogy, as the Frog proceeds from its egg without legs; ſo we ſee a great many inſects creep out of their skins without them. And as the legs and the reſt of the Frogs limbs increaſe in proceſs of time, ſome within, and others without the skin, ſo that at length it reſembles a Nymph of the ſecond order, in the ſame manner we ſee, that all the limbs of inſects, as well thoſe that are in, as thoſe that are out of the skin, grow by degrees, until they are changed into real Nymphs.

Laſtly, as the Nymph of the Frog beforementioned caſts its skin in proceſs of time, and expoſes to open view its hidden limbs, which we ſaw through the skin before, and by degrees attains its full maturity and ability for generation: ſo, after the ſame mnnner, we obſerve, that the Nymphs of inſects after ſome time caſt their skins, and ſhew their covered limbs, and, like the frogs, are rendered capable of propagating their ſpecies.

But we ſhall treat this matter more at large in the following ſheets, when we lay before the reader our own moſt remarkable experiments on Frogs; the principal part whereof has been performed before the grand duke of Tuſcany, the ſublimity of whoſe noble and accompliſhed mind, is inſpired with a generous and benevolent affection for the liberal arts and ſciences.

Let us now conſider the vegetable kinds, Tab. XLVI. *a.* for as we ſee theſe grow from a ſeed, which infolds ſome leaves, or a very tender ſprout; in like manner, we find that inſects ripen into a fuller and ſtronger habit from their ſeed, which contains all their limbs, or rather the animal itſelf wrapt up in the skin.

For the ſame reaſon that plants come in time to maturity, and ſwell under the cover wherein the flower lies, as the inſect does in the Nymph: ſo likewiſe we obſerve, that inſects inſenſibly approach to a more perfect maturity, and by ſlow degrees ſpring in their covering, or the Nymph, in which are all their limbs, as the flower is placed in its proper covering: this we ſhall hereafter demonſtrate in the Clove Julyflower, Tab. XLVI. *b.*

Laſtly, as flowers at length break out from their husks, and become capable of producing new ones by generation and running up into ſeed; in like manner inſects proceed from their Nymph, as the flower from the husk, and are alſo rendered fit for generation and repoſiting their ſperm. And as propagation is performed in plants, by the union of their ſeed with the moiſture of the earth's womb, inſects perform the act of generation, by the conjunction of the fruitful, and, as it were inviſible particles of the male's ſperm, with the conſpicuous, vivifick, and ſenſitive ſeed in the female. This ſeed of the female continues and perfects the life, motion and ſenſe which it enjoys, when the ſpermatic virtue of the male is thrown into it; and it is in this continuance of motion that the fruitful conception of the ſeed is properly ſaid to conſiſt: but we ſhall hereafter explain this matter more at large, by particular examples.

A catalogue of the inſects which are referred to in the firſt order of natural changes, called the Nymph-animal.

HAVING explained our firſt and moſt ſimple order of changes, in which we have conſidered the animalcule, which comes perfect from the egg, as a real Nymph when it is about to caſt its laſt ſkin; it now remains, that we ſhould give a catalogue of inſects which belong to this order: and upon this occaſion we ſhall briefly enumerate ſuch of them as we have in our cuſtody, as we ſhall do alſo with regard to the Nymphs, Chryſallides, and diſtinct ſpecimens of the four orders, together with ſeveral other things not unworthy the ſpeculation of the curious, which we preſerve in our cabinet, and by the aſſiſtance of which we are able to demonſtrate to the eye every thing hitherto, and that ſhall hereafter be, advanced.

To the firſt order of tranſmutations belongs the Spider *, which proceeds immediately from its egg, and has no vermicular ſtate; this has been alſo obſerved by the moſt accurate Martin Liſter, who in his elaborate treatiſe on Spiders ſays, "Theſe are hatched from the eggs, "perfect and complete in all their parts." Chap. II. Of the generation of Spiders.

I keep, for this purpoſe, the largeſt of all Spiders, that is, the venemous, Braſilian kind, which has crooked, black, very ſharp and big claws, or rather darts, and alſo has two arms, which are in all reſpects like ſhanks or legs.

I alſo have the great downy Phalangium, or Tarantula.

Alſo a very remarkable Spider which Dr. Padbrugge ſent me from the Cape of Good Hope. It is of the colour of ſcarlet velvet, and covered thick with a fine down, in which is the colour. It is as big as a grain of a ſmall French bean, with an oblong body, and broad breaſt; it has ſhort legs, except the two foremoſt pair, which are very long; the ſecond pair are ſomewhat ſhorter; the third is very ſhort; but the fourth or laſt is ſomewhat longer, and all of them are covered thick with red hair. The breaſt is ſo cloſely united to the belly, that they cannot be ſeparated from one another; therefore this Spider is in that reſpect like a Lobſter; it has two ſhort arms, and two ruddy tranſparent ſtings or darts, but its eyes can't be ſeen on account of the thickneſs of the hair.

I have alſo the American ſpecies of Spiders, which has rough, thick, and very long legs in compariſon of the body; the belly is ſomewhat ſwelled and briſtly, its darts are very much bent and crooked like claws, but the arms are ſhort in compariſon of the legs, being not above a third part of the length of the fore pair. It has eight eyes, which are neatly ranged in two rows; its breaſt is like an oval ſhield; it turns the eyes to the extreme parts, and bends itſelf a little on the inſide, behind the joint of each leg or ſhank, in the ſame manner as the ſkin ſinks between the ribs in lean and thin people; but this is common to a great many Spiders big and little.

I have alſo one of the Holland ſpinning Spiders, which, in colour and figure, reſembles Mouffet's largeſt ſpinner, but it is not half ſo large. I have obſerved in this ſpecies, that each of its eight legs conſiſts of ſeven joints; thus the firſt joint at the breaſt is very ſhort; the ſecond is much ſhorter and formed like a ball; the third is the longeſt of all; and it is for the ſake of this only, that the other joint ſeems to have been made, that this third joint may be moved with the greater eaſe and expedition; the fourth is ſomewhat bent, and by degrees grows thicker; the fifth is the longeſt except the third; the ſixth and ſeventh decreaſe in proportion, whereof the latter is provided with two large, crooked, black claws, accompanied by others of a ſmaller ſize*. The animal makes uſe of all theſe to run down the web, and to guide and govern it.

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* The generical characters of the Spider kind, as eſtabliſhed by Linnæus, are, that they have eight legs, and the ſame number of eyes, placed on the back part of the thorax. The common houſe Spider, the water Spider, Tarantula, and others, are of this genus; and theſe diſtinctive marks exclude ſome inſects, called by others by the ſame name, placing them under other heads. The long-legged Spider having but two eyes, is properly an Acarus.

I cannot determine, whether the Engliſh Spiders have the ſame properties, as Liſter ſays poſitively, “All Spiders have three joints in their legs.” But ſince this gentleman thinks that all Spiders have two antennæ, or horns, which are inſerted in the head next to, and above the darts, I ſhould not agree with him in this aſſertion; for though I have never ſeen the Engliſh Spider, yet I can eaſily ſee from other foreign kinds, and their limbs, that this is repugnant to the nature of Spiders. In order to ſolve this difficulty, I ſhall briefly relate what I have obſerved, concerning this matter, in my Spinner. By examining the Spider before deſcribed, I found that thoſe two joints, and all the other legs, are fixed to the breaſt; but with this difference, that the place of their connection with the breaſt is higher, on account of the thickneſs of the hair; and this I judged to have been done, leſt they ſhould impede the action of the limbs, wherewith the ſpicula or darts are united, and that theſe joints may move with more eaſe. I have alſo obſerved, that they conſiſt of ſix, or perhaps of ſeven joints, which I ſhall not poſitively affirm; wherefore they are, for this reaſon, like legs, as Dr. Liſter has alſo obſerved, where he ſays, “Theſe, like feet, conſiſt of certain joints.”

But what deſerves the greateſt attention, is, that every one of theſe has a claw fixed to the end of it, that is ſomewhat crooked and blackiſh: wherefore, theſe may very properly be called the fifth pair of legs; and the rather, becauſe they have their muſcles on the inſide, as the other legs have, and are rough with hair and prickly briſtles. However, many reaſons induce me to think, that they ought not to be reckoned among the legs, ſince in the whole tribe of Spiders they are not ſhaped in this manner, but in a great many they reſemble the claws of Lobſters and Scorpions. This is viſible in the Flea-Spider, in which theſe limbs very nearly reſemble a pair of tongs or pincers, only that they want the great toe, as appears by one now in my cuſtody; I am obliged to refer to this, as nothing remarkable or uſeful can be obſerved at this time, for I am writing this in the month of December; but I can demonſtrate this ſo clearly, in another ſpinning Spider I have, that there can be no room for doubting: for firſt, we may ſee two darts or arrows in this; then, theſe arms are formed with ſuch wonderful art, as not to be inferior to the inimitable workmanſhip which we admire in our own hands.

Theſe arms are divided into different joints, at the end of which we ſee a ſmall concave and convex part, covered with hair: this reſembles, in aſpect, a piece of the white of an egg divided into four parts. At the end of this ſmall part, there is in every arm a little riſing ſomewhat like a finger. There are alſo on theſe ſmall hairy parts, others worthy our obſervation, each of which is joined on the inward concave ſide, to the baſis of theſe hairy parts, ſo as that the latter may protect, and, for the greater ſafety, hide the former. The firſt of theſe parts is divided into two joints placed one upon the other, to the lower of which is joined a real but obtuſe forceps, of a mixed light red and blackiſh colour, whereby the arms are connected together. To the other joint, which is ſomewhat higher, is joined an obtuſe or blunt little claw, of a colour inclining to a bright red. We further find, that another ſmall, and, as it were, blunted part, is articulated at the root of the firſt part, whereon lies the forceps; on the end of this are three ſmall toes or crooked claws, which are not placed, nor formed, in the ſame manner, and whoſe moving muſcles are hidden in the ſmall blunted part. Thus it is plain, that theſe arms are differently framed, according to the different kind of the Spider.

From theſe inſtances, therefore, it is clear as the light at noon day, that theſe limbs or members ought not to be called antennæ, feelers or horns, but real arms, and that neither Spiders nor Scorpions have any horns. But as the brachia, or arms, before deſcribed, are formed with amazing art, I have therefore thought proper to preſerve them dried; in order to have them ready to ſhew on any occaſion.

I likewiſe obſerve, that the long-footed Spider has no feelers or horns, but its arms are provided with, at leaſt, one crooked black claw, that reaches beyond the end of the arm. The legs, with reſpect to the joints, are like the legs of the ſpinner before deſcribed; and what is properly called the foot, ſeems to be divided into two ſeveral joints, that have two claws at the end of them. But I cannot further inveſtigate theſe matters at this time, being now in the midſt of winter, and having no Spiders, but ſuch as are dried and preſerved; in which, but eſpecially in the large venomous ones, that I keep, it is very evident that Spiders have no horns or feelers.

I alſo have Liſter's ſmall crimſon Spider, but as this is alſo dried, we cannot diſcover the proportion of the ends of the arms, but we may ſee that they are ſomewhat thicker than the legs.

I obſerve in the green, ſmall, and long-bellied Spider, of that illuſtrious Engliſhman, that theſe arms have likewiſe a plain claw at the end of them. The ſame is obſervable in other Spiders which I have, nor is there any that has not the fore joint armed in the manner beforementioned.

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* There is a remarkable property in the Crab, in breaking off a wounded limb at a particular joint. This has been exemplified at large in the Philoſophical Tranſactions. If the laſt joint of a leg be wounded, the Crab, by a peculiar motion, breaks off the limb at a peculiar place above, and a new one grows in its place. The ſame happens in ſome ſpecies of the Spider.

I think, I obſerve a very remarkable texture in the arms of the Wolf Spider, which I cannot now thoroughly inveſtigate.

As to the Spider's teeth, I do not find that they have been hitherto deſcribed by any author, ſince the parts ſuppoſed to be teeth, are, in reality, the creatures weapons or darts, by which it takes and kills little animals, afterwards ſucking their blood. But to ſpeak firſt of the darts, it is to be obſerved, that they are two crooked, kind of horny, and ſharp parts, like the claws of birds of prey, and are ſituated in Spiders immediately under the eyes: but they are articulated with two ſtrong, firm, kind of horny and muſcular ſubſtances, which are obſerved to be fixed under the bottom of the breaſt, in which the eyes are placed. I have ſeen clearly in my Spinning Spider, which is like that of Mouffet, as I before obſerved, that theſe firm little bones grew on the inſide, like certain blackiſh eminences or juttings like teeth, between which the ſpicula, or darts, were ſecurely and ſafely incloſed, as the moveable blade of a knife is in the groove of its handle.

I have not, on the narroweſt inſpection, been able to find the leaſt opening in theſe darts, by which the inſect might eject any venomous liquid; ſuch an opening as we ſee in the teeth or ſtings of the Worm called the Sica, or Sicarius, or Aſſaſſin, or ſuch as it is ſaid are to be ſeen in the teeth of Vipers. I have not even been able to find any apertures in the ſtings of the biggeſt venomous Spider called Phalangium, though as long as half a joint of the firſt finger.

Neither could I ever perceive that Spiders, however irritated, diſcharged any virulent matter, though I have ſpared no pains or attention to obſerve them. Doctor Liſter alſo ſeems to have made the ſame remark, and I ſhall willingly ſubſcribe to his opinion; till experience may inform me otherwiſe.

It is very ſurpriſing, that ſuch ſtrong and ſolid muſcles ſhould be contained in the horny ſubſtance of thoſe parts, to which the ſtings are faſtened. I have a method of extracting theſe muſcles entire, in anatomizing the inſect; and the ſame may be obſerved of the muſcles ſerving to move the claws of Crabs. No doubt, theſe parts agree much with the internal claws or pinchers of Scorpions, who likewiſe carry them under their eyes; and was it true that Spiders, on wounding any animal with their darts, diſcharged a poiſonous liquor along them into the wound ſo made, we might then ſay, that the darts of this inſect and that of the Scorpion were perfectly alike; excepting this, that the Spider's weapons are placed on the fore part of its body about the mouth and breaſt, whereas that of the Scorpion is fixed to its tail; beſides, the Spider has two darts, and the Scorpion only one. But it is above all things worthy obſervation, that in the Spider with two eyes, theſe darts are joined and formed into real forceps, as the indefatigable Liſter has obſerved, and I have myſelf diſcovered this to be the caſe in ſome long footed ones which I dried: ſo far therefore theſe parts agree in make with the internal forceps of Scorpions.

As to the true and proper teeth, I have found them ſituated forward on the lower part of the thorax, immediately under the points of the darts, where they ſhut one cloſe to another; in the ſame manner that I have obſerved in the little crabs, and as may be ſeen in the Cray-Fiſh. They are alſo faſhioned in the ſame manner, but of a ſubſtance not ſo horny. On pulling out theſe teeth, it appears that they are united with certain other little pieces; which may not improperly be called articulated briſtles. We have here therefore a ſatisfactory ſolution of the phenomenon, ſo judiciouſly obſerved by doctor Liſter, viz. that there may be found in the excrements of Spiders, ſome particles of the Flies they have devoured. His words are, "You would imagine they only lived by ſucking the juices of the Flies they catch, if you were to view nothing but the dead carcaſſes of thoſe Flies; but if you attentively examine the excrements of the Spiders, you will find in them particles of their ſkin or coat." Spiders, therefore, actually devour ſome parts of their prey, and ſuck the juices from other parts of it, which they can eaſily and conveniently do, when they ſqueeze it between the denticular proceſs of thoſe parts, where their darts are inſerted, and draw in its blood and juices. They are able to do this the more eaſily, as their darts terminate oppoſite to their teeth; for under the teeth there may be obſerved a little piece like a lip, and this proceſs covers ſome part of them.

As to what regards the eyes of theſe creatures, I cannot at preſent examine them to my ſatisfaction, the days being ſhort, and the weather very cold and cloudy; beſides which, I have but one of theſe Spiders in my cabinet, placed there for the ſake of obſerving, whether the ſevereſt froſt would not entirely ſtiffen it, as is the caſe with Butterflies, and common Flies. But as I had doctor Liſter's work, it induced me to undertake the diſſecting of this ſingle Spider, though I had at firſt intended to ſay nothing of Spiders in particular at this time. I diſcovered that its two uppermoſt eyes were ſomewhat bigger than the others. This difference is very ſtriking in the Flea-Spider, as it was evident from a drawing I formerly took of this laſt inſect; in which I have repreſented its ten eyes. But neither can I now examine that kind of Spider ſo accurately as I could wiſh. Which way ſoever the fact may lie, I find the two eyes that are placed above the eight others, are repreſented very ſmall in my drawing.

I have carefully examined alſo, whether in the aſperæ arteriæ of the Spider, there were any openings; but I could find none in the thorax, nor any which ran into the belly: I only diſcovered in this kind of web Spider an oblong member, like the penis of many animals, ſituated in the middle of its belly, on the outſide of its body, on a very prominent place near the thorax; and near this member there were two yellowiſh ſpots in the form of moons, covered with a ſofter ſkin than the other parts of the belly.

But not to dwell too long upon theſe parts, the following are the principal of the others, which occurred to me on examining this Spider; beſides eight eyes ſituated in the head and thorax, and on the fore part under the eyes, the darts with their joints; behind and under thoſe darts in the thorax, appeared its mouth and teeth; then beyond theſe were two arms with their claws, and after theſe eight legs, each with ſeven joints and two claws at their extremities; add to theſe the belly, with its peniform member, and the down, and ſharp briſtly hairs, with which the ſkin both of the body and legs are all over covered.

I cannot yet ſay much of the internal parts, but I may affirm, that I ſaw very diſtinctly the muſcles of the legs, claws and darts; I could likewiſe perceive that the thorax was quite full of muſcles, ſo as hardly to contain any thing beſides the mouth, heart, and ſpinal marrow; but I have not obſerved theſe muſcles of the thorax diſtinctly enough, to be able to affirm any thing certain concerning them.

The muſcular integument of the belly was very eaſily ſeparated from the inteſtines which it contained; and under this there appeared an elegant piece of net-work, like an omentum or cawl, conſiſting of globules delicately fixed to one another, and of a whitiſh purple colour.

On opening this omentum, I thought I could perceive the abdomen, which was ſhaped like the tendril of the vine; then firſt appeared pretty diſtinctly the inteſtines, through which there ran here and there whitiſh veſſels, which I took for productions of the aſpera arteria. Next there came in ſight a tranſparent yellowiſh maſs of a globular figure, which might be taken for a ſtring of eggs, if the peniform particle or member already obſerved had not indicated the creature to be male; and conſequently this ſomething elſe.

The little bag, in which the Spider carried the ſtuff for its web, like ſoft glue, was twiſted into many coils of an agate colour; and upon breaking it, the contents were eaſily drawn out into threads: but as I made all theſe obſervations in haſte, and in the firſt diſſection of a Spider that I ever ſet myſelf about with attention, I neither can, or dare vouch, for the perfect certainty of them all. I refer to ſome other opportunity a more careful ſurvey of this moſt curious ſubject.

In the mean time, we have great reaſon to be concerned that doctor Liſter did not think proper to finiſh his excellent work with the anatomy of all theſe parts; which would certainly have been a moſt valuable addition to ſcience. He has laboured ſtrenuouſly in the other parts, every where giving proofs that he wrote his hiſtory in an accurate and regular manner from his own obſervations. This is the reverſe of what the generality of modern writers practiſe, who do nothing but plunder each other, and then, like Æſop's crow, adorned with the feathers of other birds, and weakly glorying in their borrowed finery, perſuade themſelves that what they have pillaged from others, is the offspring of their own brain, though they do not ſo much as underſtand it. We may the more readily excuſe ſuch high notions in them, when we know they are no more than the monſtrous productions of a heated imagination.

Of the Flea Spider I preſerve two kinds. Theſe ſeize their prey by a ſudden leap, and therefore nature has provided them, as well as other Spiders, with eight eyes, and a moſt acute ſight: it is more difficult to judge of this ſight in the Spiders that make webs; for ſo far from taking notice of a finger put cloſe to their eyes, they neither expreſs any concern at it, nor attempt to run away; whereas, let the moſt minute animal fall into their nets, they immediately perceive, and lay hold of it. This apparent inſenſibility on the one hand, and readineſs of perception on the other, has made ſome philoſophers think the web Spiders had no eyes, but received information only concerning their prey, by the tremulous motion of their web. When theſe gentlemen further conſider, that what look like eyes in Spiders, never appear when viewed with the microſcope of a reticular form, as is the caſe in the Scorpion: they more roundly deny that they have any eyes. But it by no means follows from the web Spider's never leaping upon its prey, or from its never running to it, unleſs when taken in its net, that it has no eyes; and this concluſion muſt appear yet weaker, on conſidering that eyes are as diſtinctly perceivable in this kind, as in the Flea Spider, and withal are diſpoſed in the ſame manner. As to the argument drawn from the parts which look like eyes in web Spiders, not being formed in the reticular manner, as in other inſects, it is equally unſatisfactory: for what difference is there between its eyes being placed ſingly in different parts on the ſurface of the body, as in the Flea Spider, and their being gathered into one net as in other inſects? beſides, the eyes of Spiders thus ſcattered, are much larger than thoſe which form the netted eyes in other inſects; ſo that, every thing duly conſidered, there is reaſon to affirm, that Spiders have a more perfect ſight than the generality of other inſects, except the Libella or Dragon Fly, which appears to have very large, or very numerous complex eyes, ſo as to afford an opportunity of trying upon it many curious experiments. Thus, has nature diſplayed her wonders, even in thoſe little animals, which, at firſt ſight, appear to many beneath their notice; at the ſame time that ſhe ordains the largeſt animals to proceed originally from principles, or eggs, as little conſpicuous as thoſe from which theſe minute inſects derive their beings: this we have already obſerved.

But let us return to the Flea Spider, in which the providence of nature is very conſpicuous, having ſupplied it with a thread by which it may ſwing, and be ſecured from any ſudden fall; if at any time it ſhould fail in the ſprings it makes: however, this thread becomes an obſtacle to its catching any, except very little, animals, when it has remained any time in the ſame place. Though this inſect makes uſe of no net to catch its prey, it ſpins itſelf, like many other Spiders, a web to fly to, and to hide in, on being purſued. Another thing worthy our notice in the Flea Spider, is, that on pointing your finger to it at a diſtance, it wheels and turns itſelf about every way you move and turn about the finger; and runs off, on your putting the finger nearer. Laſtly, as I have already obſerved, there are amongſt the Flea Spiders which I keep in my cabinet, ſome, the extremities of whoſe claws are found like the forceps of Scorpions, except that they are not jointed, but ſhut in a manner like the forceps of the Cray-Fiſh.

I have beſides theſe a Hedge Spider, which, to hatch its eggs the better, carries them about, as it were, in a caſe, with wonderful ſolicitude and affection; inſomuch, that when the ſkin forming this caſe, which hangs to the hinder part of its body, is by any accident broke off, the little inſect ſeeks after it with as much earneſtneſs and induſtry, as a Hen for her loſt Chickens; and when found, faſtens it again to its place with the greateſt marks of joy. A deſcription of this Spider may be ſeen in Harvey's Treatiſe on the Generation of animals, and more perfectly in doctor Liſter, who with great propriety calls it the Wolf Spider *.

I preſerve alſo in my collection, ſome bags in the ſhape of eggs or pearls, in which Spiders put up their eggs, and hang them, as in a baſket, to the beams and floors of houſes. I have ſometimes obſerved ſmall Flies to come from theſe nets, and have by me ſome of the Flies thus produced. It would demand too much compaſs, for this place, to enlarge at preſent on this ſubject as much as it deſerves.

To conclude, I preſerve likewiſe that ſpecies of long-legged Spiders, which Goedaert, to whom the learned world are obliged for the drawing of about four hundred inſects, has exactly deſcribed, in the forty-ninth experiment of his ſecond volume. He there, in the drawing of this inſect, moſt evidently demonſtrates, that it is a true Nymph at the time when it is about to throw off its ſkin for the laſt time; for its legs at this period are lengthened in a very remarkable and ſurpriſing manner. The accurate Liſter has alſo remarked, that Spiders ſometimes are not fit to enter upon the buſineſs of generation, till they are almoſt two years old; which, no doubt, proceeds from this, that nature intends they ſhould ſo long continue growing, before they part with their laſt ſkin, and with it, the form of a Nymph. Before this time they are not fit for generation, and after they are, they never change their ſkin.

We are likewiſe greatly obliged to the late accurate James Hoeſnagel, painter to the emperor Rudolphus, who has left us the drawings of thirty-five Spiders, and of about three hundred other inſects of different kinds; which drawings, taken after the life, have been ſince publiſhed from copper-plates, with the privilege of his imperial majeſty, and are in no reſpect inferior to thoſe of Goedaert.

Wenceſlaus Hollaar has alſo applied himſelf to this ſtudy, and deſerved well of the publick, by his moſt exact drawings of the inſects preſerved in the Arundel Muſæum. It were greatly to be wiſhed, that all thoſe who would be thought to have any extraordinary knowledge of inſects, did the ſame, that by their joint labours this branch of natural philoſophy, which is by no means of the leaſt account, may be brought to perfection. A thorough acquaintance with the diſpoſitions and actions of theſe little animals, would enable us to form the better judgment of the diſpoſitions and manners of innumerable others.

Before I quit the conſideration of Spiders, I think it will be agreeable to ſhew in what manner thoſe kinds which ſpin webs, or live upon Flies, get from one tree to another, which they will do; even when ſeparated by a running water. It will be firſt proper to mention, that the Spider's thread is by no means ſingle, but almoſt always double, and ſometimes even ten or twelve fold. This may be eaſily ſeen by throwing down a Spider, and immediately examining the thread to which it hangs. Or it may be obſerved, with ſtill greater eaſe and certainty, by ſeparating the hinder part of a Spider from its fore part, and then drawing out the thread, and afterwards examining it. As therefore the Spider's thread is generally made up of two or more parts, after deſcending by ſuch thread, it aſcends by one only, and is thus enabled to waft itſelf from one height or tree to another, even acroſs running waters; the thread it leaves looſe behind it, being driven about by the wind, and ſo fixed to ſome other body. This opinion of Spiders making uſe of a double thread, has already been advanced by Henricus Regius, profeſſor of medicine at Utrecht, and that eminent naturaliſt Franciſcus Redus.

But the accurate doctor Liſter produces ſome diffierent obſervations on this ſubject; he ſays, that Spiders, in this caſe, ſhoot out their threads. His words are as follow: "Some "Spiders ſhoot out their threads in the ſame "manner that Porcupines do their quills, with "this difference only, that whereas the quills

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* The Wolf Spider makes no web, but lives at large upon dry banks and heaths, perſuing his prey or ſeizing them by ſurpriſe; and is very nimble and very bold.

“ of the latter are entirely ſeparated from their “ bodies when thus ſhot out, the threads of the “ former remain fixed to their anus; as the ſun's “ rays to its body.” And in another place, “ Spiders that are middle-aged, or of a mode- “ rate bigneſs, truſt themſelves to gentle winds “ by means of a thread, and thus endeavour, “ as it were, to aſcend into the clouds, and “ the upper regions of the atmoſphere.” As to the firſt of doctor Liſter's aſſertions, I cannot at preſent take upon me either to countenance or contradict it; I only wiſh he had explained himſelf more clearly; for how is it poſſible that the thread of a Spider, which is ſo fine and ſlender, ſhould be ſhot out with force enough to divide and paſs through the air? Is it not rather probable that the air would ſtop its progreſs, and ſo entangle it, and fit it rather to perplex and obſtruct the Spider's operations? I know very well, that a man may drive out his urine to a conſiderable diſtance, in the form of a ſlender thread; but this urine is a liquid, which is not the caſe with the Spider's thread; beſides, it does not appear that the Spider carries all the matter of which it compoſes its threads, in a ſingle cavity, ſo as to be able to throw it ſo far, if it could do it, even in a ſolid form. Moreover, there ſeems requiſite for this purpoſe a great ſtrength of muſcles, and a conſiderable exertion of ſuch ſtrength; whereas that part of the Spider from which its thread iſſues, does not appear to have any muſcles: theſe are conjectures only, which time will overthrow or confirm.

As to doctor Liſter's laſt aſſertion, there is no great difficulty in comprehending it. I have myſelf often obſerved ſmall Spiders ſupported and driven about in the air, by means of a thread, in the ſame manner with that little paper machine called a kite, with which children divert themſelves. If therefore doctor Liſter, in ſaying that Spiders when come to their full growth ſhoot their thread, means only, that they let it fall looſe from their bodies, to be taken hold of by the wind, and lengthen it by a continual ſending out of the matter that compoſes it, there can be no objection to his doctrine. For my part, nothing more as yet appears to me on this occaſion, than that all Spider's threads are drawn from the inſect's body, by its own weight or effort, without any compreſſion while it deſcends or moves forward, as the threads of the Silk-Worm are drawn, and by no means ejected, from the bags in which the matter forming them is lodged. I can yet more eaſily comprehend how, Spiders without giving themſelves any motion, may, by only compreſſing their anus, ſpin out a thread, which being driven by the wind, may ſerve to waft them from one place to another.

The dart of the Tarantula is ſaid to occaſion a peculiar frenzy [*], which the ſame authors ſay is cured by muſick, but this ſeems an impoſition. A very curious gentleman lately arrived here from Italy, has aſſured me, that it is looked upon as a mere fable, even in the country where the creature is moſt common; and that none but the lower ſort of people, beggars and vagabonds, pretend, on being hurt by thoſe venomous creatures, to find any relief from muſick. They pretend this, that by impoſing on the credulous, they may live without betaking themſelves to honeſt labour. And thus we ſee amongſt ourſelves, the people called Gypſies, by ſetting up for prophets, prey upon the ignorant and illiterate.

To finiſh what I have to ſay in this place concerning Spiders: I am to obſerve, that doctor Liſter very accurately divides them into what he calls fowlers, viz. ſuch as take their game in nets, or by ſtinging it, and into hunters with eight eyes, which he diſtinguiſhes from thoſe with two eyes and long legs. Doctor Hooke has favoured us with very curious drawings of the beſt kind, and I intend to publiſh diſſections of them on ſome ſucceeding occaſion; that ſo the hiſtory of theſe inſects may, by our joint labour, be brought to the perfection it deſerves, and ſupply us with new motives to love and reverence God, the author of all the miracles we obſerve in them: this ſhould be the ſole end of all our endeavours and ſtudies.

I ſhall next refer the Acarus [†] to the firſt order of mutations, as it iſſues from its egg, perfect in every thing but ſize, which it afterwards acquires by degrees.

In the ſame order too I ſhall place the common Louſe [‡], which has a Nit for its egg; but as this iſſues very ſuddenly from its egg, or rather, as what we call the egg is in reality the Louſe itſelf, which only waits to be freed from the ſuperfluous moiſture that ſurrounds it, to eſcape from its cover; it is an eaſy matter to conceive, how this little inſect can multiply ſo faſt, that people ſay in ſport, but it is no more than a jeſt, that a Louſe may ſee its fourth generation in the ſpace of twenty-four hours [§]. Theſe Nits muſt be laid in a place that is warm, and moderately moiſt, to produce any thing. This is the reaſon that many Nits laid on the hairs in the night-time, are deſtroyed by the cold of the ſucceeding day, and ſo ſtick for ſeveral months, till they at laſt come to loſe even their external form.

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[*] Bonone mentions a large Spider in Sardinia, whoſe bite proves mortal in a few hours.

[†] The generical characters of the Acarus, are, that it has eight legs, and in each leg eight joints, and has only two eyes. According to this diſtinction, eſtabliſhed by Linnæus, and now adopted by all naturaliſts, the long-legged Spider, and many of the creatures infeſting birds and beaſts, and commonly called Lice and Fleas, are truly Acari.

[‡] The generical characters of the Louſe, according to the Linnæan ſyſtem are theſe: it has ſix legs, contrived for walking, not for leaping as in the Flea; the eyes are two, and they are of a ſimple ſtructure; and the body is divided by indentings into ſeveral lobes.

[§] Lewenhoeck, who put a male and female Louſe under a ſtocking which he wore night and day to favour their breeding, found that the female lays from fifty to a hundred eggs; and computing the natural increaſe from what he had ſeen, ſays, that in eight weeks, one Louſe may ſee five thouſand of its deſcendants.

In examining a Louſe by the microſcope, its white veins and other internal parts appear, as likewiſe a moſt wonderful motion in its inteſtines, on account of the tranſparency of the internal parts of this inſect. When the Louſe feeds, the blood is ſeen to ruſh like a torrent into the ſtomach, and its greedineſs is ſo great, that the excrements contained in the inteſtines, are ejected at the ſame time, to make room for this new ſupply. But I ſhall treat of theſe inſects in particular, as ſoon as I ſhall have finiſhed what I propoſe ſaying in general of theſe that belong to the firſt order.

What I have already mentioned is but by way of parentheſis, that my countrymen might know ſomething of the ſtupendous actions and conſtructions of ſo ſmall an animal, and be thereby incited to praiſe the author of nature, who has here placed in one point of view ſo many and ſo great wonders. The great uſefulneſs of the microſcope will alſo appear from the preceding obſervations, ſince, by diſcovering to us the muſcles, veſſels, and internal parts of ſo ſmall an inſect, it acquaints us with the incomprehenſible perfections of that great being, who could not only create, but impart life and motion to ſo minute organs. There is another advantage alſo in microſcopes, viz. that in tranſparent animals, they give us a much more perfect knowledge of the motion of their inteſtines, than any we can obtain in other creatures by diſſecting them. This benefit of the microſcope has been already taken notice of by the illuſtrious Hooke, in his Micrographia, or collection of obſervations made with microſcopes, a work lately publiſhed in Engliſh, and dedicated to his Britannick majeſty.

I have reaſon to believe, but for want of ſufficient experiments I dare not as yet affirm, that the Lice of other ſanguiferous animals, and the Lice of inſects, with thoſe that live upon plants, or ramble about the fields, belong to the laſt mentioned order or claſs [*]. Mean time it will appear evident, in treating of the fourth claſs, that there are ſome tree Lice, deſcribed by me under the title of animalcules, found in the excreſcences of the black poplar, which belong to the ſecond order.

Neither can I affirm, that the Tick, or Ricinus of Aldrovandus, though placed by me in this claſs, does really belong to it; though I have in my collection a good ſpecimen of this inſect.

I likewiſe refer the Bug which lies in bedſteads and furniture to this firſt claſs; as alſo the Crab-Louſe, though I have not as yet made experiments ſufficient to determine perfectly the nature of this laſt inſect.

I have alſo in my collection the Louſe of the Whale, which is almoſt an inch long, and half an inch broad, of a very ſingular form, and all over covered with a ſhell [†].

After theſe, I rank the Flea [‡] in the firſt claſs. This inſect alſo ſprings from a Nit, in the which it elegantly changes to a red colour, like other inſects in the Nymph ſtate; the changes it undergoes, while as yet in the ſtate of the Nit, and the manner in which it from white becomes black, are eaſily diſcernable by the help of the microſcope: nor are theſe obſervations of little uſe or importance, as I ſhall hereafter prove at a proper ſeaſon. I have been told that Doctor Lewenhoeck obſerved a Flea at Delft, which, about the end of ſummer, iſſued from an egg in form of a Worm, and then ſhut itſelf up in a caſe till the enſuing month of March; but I ſhall not as yet affirm the certainty of this obſervation; neither ſhall I determine whether the Flea wore in its caſe the figure of a Chryſalis, or a Nymph; if it did, the inſect muſt belong to the third, and by no means to the firſt order. I ſhall uſe the firſt opportunity of exactly obſerving this inſect, ſo as to know the certainty of what has been advanced concerning it, as ſuch enquiry cannot be attended with any great trouble [§].

I likewiſe place in this firſt claſs an inſect which is generally found in ciſterns where rain water is kept, and which Goedaert has deſcribed by the name of the Water-Louſe, as may be ſeen in the third volume, letter X. But as the ſtructure and diſpoſitions of this little animal differ greatly from thoſe of the common Louſe, though it be at the ſame time equally ſingular and remarkable, I have given drawings of it, both of its natural ſize, and as the microſcope repreſents it, in the ſpecial treatiſes on inſects of this firſt claſs, under the name of the water arboreſcent Flea *. Theſe drawings are exhibited in Tab. XXXI, and a complete deſcription of the inſect immediately follows that of the Louſe.

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[*] Redi, who very accurately examined this ſubject, found Lice upon the Lion and the Tiger. He calls all thoſe on quadrupedes by this name; and thoſe on birds, Fleas; but he is in this miſtaken, the diſtinctive characters are to be found in the ſtructure of the parts, not on the creatures whereon they feed. The ſame author obſerves, that the Lice bear no proportion to the bigneſs of the creature on which they live, the Starling having a Louſe as large as that of the Swan.

[†] The common Fly is ſubject to a particular inſect which lives upon his head; this is ſo minute that few have obſerved it; its ſize is calculated by La Hire of the French academy, to be not more than a four thouſandth part of that of the head of the Fly. This is of the Acarus kind, having eight legs.

The Crab-Louſe upon the human body is of the ſame genus with the common one of the head, but a different ſpecies. It is deſtroyed by mixtures with water, in which crude mercury is boiled.

Even the Snail is ſubject to be infeſted with a kind of Louſe, but in a very ſingular manner; for this creature, which has eight legs, and is of the Acarus kind, lives equally on the ſurface of the body, and within the inteſtines, running in and out at its pleaſure. It is uſually ſeen alive in the inteſtines, when they are examined by the microſcope.

[‡] The common Flea is an extremely ſingular inſect, there being no other ſpecies properly of its kind: the generical characters are theſe; it has ſix legs formed for leaping, the eyes are only two, the organ which ſerves for a mouth is bent downwards, and the belly is roundiſh and compreſſed. Only the Flea of the human body has theſe characters; what is called the Pulex Sturni is an Acarus, and the reſt of the inſects which have received this name from inaccurate obſervations, belong to other genera.

[§] Though the Flea is peculiar in the human kind, it is not ſo with the Louſe. Multitudes of animals, birds and beaſts, are infeſted with Lice, and though of different ſpecies upon moſt kinds, they all have the characters here deſcribed, and are properly of the Pediculus or Louſe kind. Inſects have alſo leſſer inſects living upon them, particularly the Beetle; but though theſe are called Lice, from their living on other animals, they are not of that kind. The Louſe of the Beetle, as it is commonly called, has eight legs, whereas the proper Louſe has but ſix: this creature is properly an Acarus, and ſo of the other.

I now paſs to the Aſellus, or wood Louſe, which is found of all ſizes †, and may, partly for that reaſon, and partly for others, be ranked in this firſt claſs. I have in my collection three kinds of this inſect; the firſt is the common ground Aſellus; the ſecond has great, black, prominent eyes, a diſtinct head, and a thorax like a hood; the third kind is very remarkable for folding itſelf into a ball when handled, and remaining for ſome time in that poſture.

I likewiſe preſerve ſeveral skins thrown off by Aſelli, ſloughs or dead skins, which ſtill exhibit the exact figure of the inſect. Theſe ſloughs produce a great fermentation, when mixed with acids; whence we may juſtly infer, that they contain a great deal of alcaline ſalt, and therefore may be of great ſervice in curing the dropſy, ſtone, and gravel in the kidneys.

I likewiſe have in my collection ſome ſea Aſelli. I give them this name, becauſe they are found in ſalt-waters. The largeſt of theſe is one that meaſures two inches and a quarter in length, and one inch and a quarter in breadth; it conſiſts of eight rings, of a firm and bony ſubſtance. I have likewiſe a very ſmall Aſellus of the ſame kind, which I caught in the North ſea near Petten. Doctor Padbrugge ſent me from the iſland of Ternate, another ſpecies of Aſellus, under the name of the ſea Louſe. It is almoſt half an inch long, conſiſts likewiſe of eight rings ſomewhat coloured, and, like the Sea Hedge-hog, or Echinus, has a border of ſmall prickles; but theſe inſects have no legs.

I preſerve alſo ſome other kinds of ſea Aſelli, more curious than theſe already mentioned, amongſt which there are four, whoſe ſhape is like that of the Shrimp. The firſt of theſe, which is the biggeſt, is an inch long, has a ſlender body, ſeven legs on each ſide, like the ground Aſſellus, and large horns which meet in a ſharp point; the laſt ring of the body in this ſpecies is much longer than the reſt, and running out into a three-pointed extremity. The ſecond and third kinds are much ſmaller, but almoſt of the ſame ſtructure. The fourth differs from the three kinds already mentioned in this, that its fore legs are much longer than its whole body, and theſe are divided into four very diſtinct joints. It is likewiſe the ſmalleſt of the four kinds, not exceeding half an inch in length, even when its claws are ſtretched out to their greateſt extent.

I preſerve alſo a broad ſea Aſeilus, ſent to me from Iceland; it is an inch long, half an inch broad, and compoſed of ſeven rings, including the head and tail. Its antennæ or horns are ſharp and ſhort, its eyes are brown, its ſix foremoſt legs are armed with ſharp and crooked claws, and near its tail, on both ſides, are two flat fins. Olaus Borrichius obſerves, that the whole body of this inſect appears to be ſupported by a ſimple bone, not unlike in ſhape to a ſmall date, but of a horny or cartilaginous ſubſtance. I have ſome of the ſame, kind but very ſmall, which I took in the ſalt-water river that runs by Amſterdam. I can alſo ſhew a very uncommon kind of ſea Aſellus, which I caught near Petten; it is ſcarce an half inch long, of a globular but ſomewhat oblong form, reſembling a pear, with a pretty long tail, and ſome fins. I preſerve with theſe ſome Scrophulæ, which belong to the genus of Aſelli. The firſt of theſe I caught on the coaſt of the North ſea; it is very ſmall, always runs, and ſometimes ſwims ſlantingly, and when aſhore leaps as the Flea does.

Amongſt the Scrophulæ which I have taken in the freſh waters and rivers of Holland, is to be mentioned, that kind which is called Snel. This has a pretty way of running ſlantingly, and if we may believe the tales of fiſhermen, it readily kills the Perch, by running itſelf ſuddenly into the gills of that fiſh. We have no experience to confirm this tradition. I know, indeed, that this little animal is furniſhed with arms ſufficient for the purpoſe: being held in the hand, it excites a kind of tingling: now the gills of Perches, and indeed of all fiſh, are ſo tender and delicate, that it is almoſt impoſſible they ſhould not die on receiving wounds in that part, through which all the blood of fiſh is circulated, in the ſame manner that the blood of other animals is all circulated through their lungs. This kind of Scrophula is found equally in freſh and ſalt waters.

After theſe follows properly the Worms, which ſome have called the inteſtines of the earth. Theſe proceed immediately from the egg, and do not afterwards undergo any change, coming forth at their full perfection. The females, from their firſt hatching, have their little eggs, which are very diſtinct and perceptible. I obſerve, that this genus may be divided into many ſpecies.

Though it is no hard taſk to diſtinguiſh in ſeveral kinds of Worms and Caterpillars the males from the females, by carefully examining them, but chiefly by diſſection, to ſee if they have any eggs within them, yet they ſel-

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* Latter diſtinctions do not permit us to give this ſingular creature the name Pudex or Flea. It is of the monoculous kind, the charactersof which, according to Linnæus, are, that the fore feet are branched, and are found equal for ſwimming or for leaping; that the eye is ſingle, but compoſed of three, and that the head has a cruſtaceous covering.

† The characters of the Aſellus are, that the body approaches to an oval form, and the tail is ſimple, and not foliated. The number of legs is uncertain, ten, fourteen or ſixteen. The genus is now called Oniſcus. The plain tail diſtinguiſhes it from the Shrimp kind; and ſome others which approach to it in many reſpects, but by their leafy or foliated tails are referred, though ſmall, to the Crab kind.

dom copulate while in the Worm ſtate; ſo that Goedaert ſeems to advance a paradox, when, in the ſeventy-fourth experiment of his firſt part, he repreſents as a male Worm, an inſect which he afterwards, on its having undergone the uſual change, calls a female, in the ſeventy-fifth experiment. This is the ſame as if an infant, who we called a boy, we ſhould afterwards, on his arriving at the ſtate of maturity, denominate a woman. But I ſhall ſpeak more of this hereafter. In the mean time I muſt remark, that my reaſon for animadverting thus freely on the miſtakes of others, is, that ſucceeding writers may take the ſame liberty with me, by which means truth will at length univerſally triumph; for I am well aware how much we are apt to be pleaſed with our own conceits, and how often deceived by that fondneſs, ſo as to take them for the true repreſentations of nature. However, I have no great reaſon, I think, to dread the ſevereſt inquiry into my obſervations, ſo that I with pleaſure give them up to the examination of thoſe who ſhall think it worth their while to compare them with the things themſelves, which is the only method of coming to a certainty, in inveſtigating what belongs to the animals of which I have been treating. Nevertheleſs I muſt candidly own, that many of the particulars I have mentioned as yet, appear ſo obſcure to me, that I can at moſt but conſider myſelf as a novice in this buſineſs; beſides, that words are wanting often to expreſs the wonders which occur in the ſtudy of inſects.

Scorpions * belong to this claſs of the inſect kind; they are produced from an egg like the Louſe, as will appear in the account I ſhall give of them in particular, after the hiſtory of the water arboreſcent Flea.

I am of opinion alſo, that the Leech † is to be arranged in this claſs, though I have no particular experiments to confirm that opinion, except its being found of almoſt all ſizes. It is very remarkable how firmly this inſect will faſten itſelf to the ſides of the glaſs veſſels in which it is kept, ſo as not to be ſeparated from them without the greateſt difficulty. This, I apprehend, it effects by preſſing its body cloſe to the glaſs, and then ſwelling it in the middle, ſo as to repel the water in which it ſwims. Thus, if we apply to a ſtone a round piece of leather, with a ſtring fixed to the center of it, and then pull this ſtring, the ſtone and leather unite very firmly together ‡.

I refer alſo the Scolopendra, or Centipes, to this claſs, as I have met with this inſect of all ſizes, and could never yet diſcover that it changed its form. I have got one of the largeſt kind, which is even a ſpan long, and was ſent me from the Eaſt Indies. I preſerve alſo other kinds of this inſect, as the Lybian Scolopendra of Mouffet, and the water Scolopendra, and in fine, ſome Juli, or Gally Worms, which we ought to rank with this kind.

After theſe inſects follows the Snail, as proceeding directly from an egg, and not being liable afterwards to any change. I preſerve a ſort of Snail, in which, on cutting off the head, is found a ſtone, called the ſnail ſtone, ſaid to be ſerviceable in the gravel and ſtrangury. Under this ſtone we always find the heart, which retains a pulſation, and is, with the veſſels that ſpring from it, of a very white colour. As on cutting off the Snail's head, this ſtone is always to be met with, it ſeems probable, that it ſerves for the ſame uſe as the Os Sterni does in other animals: it is further obſervable, that nature has formed Snails in ſuch a manner, that they void their excrements at their neck, breathe at their neck, and have there alſo all the parts ſubſervient to generation. I have obſerved alſo, that every Snail is both male and female; in a word, a perfect hermaphrodite: the penis is formed like that of the Whale, and is of a ſurpriſing length. But I ſhall hereafter treat of all theſe particulars more at large. The Engliſh authors, who publiſhed a catalogue of the plants that grow in the neighbourhood of Cambridge, have already obſerved, that Snails are hermaphrodites.

To come to a concluſion, I preſerve alſo in my cabinet the teeth of Snails, which are flexible, and of a horny ſubſtance; as likewiſe the heart of a Snail with its auricles, preſerved in a balſam, and properly inſected.

All the inſects hitherto mentioned iſſue directly perfect into light, and are never changed into motionleſs Nymphs; for their eggs, without any intermediate ſtate, afford young inſects exactly like the old ones, which grow to their due bigneſs in time, whilſt their limbs acquire firmneſs and ſtrength. Nor do they in this reſpect differ from thoſe other animals, which Harvey tells us proceed from a perfect egg, though before they attain their full growth, they may be obliged to change their ſkins, and ſome of them in their laſt change of their ſkin undergo ſome further changes: for this reaſon I have conſidered them as Nymph animals. Beſides, ſome of them, like mankind and quadrupedes, hatch their eggs within their bodies, and are therefore viviparous. This is the caſe with Scorpions, and ſome ſpecies of Snails.

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* The generical characters of the Scorpion, as now eſtabliſhed by Linnæus, are, that it has eight legs, with claws on the forehead; eight eyes, two on the upper part of the thorax, and ſix at the ſides, with a tail armed with its ſting.

† The Leech, like the Earth Worm, conſtitutes a particular genus of inſects; the characters are few and plain; the body is ſimple, and is expanded into breadth at each end: we have two kinds common in ſhallow waters, the Leech uſed for bleeding, and the cylindrick kind.

‡ Morand, in the memoirs of the academy of ſciences at Paris, has accurately deſcribed the mouth of the Leech; it conſiſts of five parts, two lips, a hollow for receiving the blood, an inſtrument to pierce the ſkin, which is compoſed of three ſharp points, and an Œſophagus for ſwallowing the blood. The Leech will live in oil, which is deſtructive of moſt other inſects, if only rubbed upon their ſkins. The Leech, when taken out of oil and put again into water, caſts a thin and very delicate ſkin.

The natural changes of the firſt claſs or order of inſects, exemplified in the Louſe; with an explanation of what relates in general to the other three claſſes.

THAT I may give a ſingular and ſatisfactory ſpecimen of the firſt claſs of inſects, I ſhall here inſert a letter, formerly wrote with great care to Mr. Thevenot, as it contains a complete and exact account of the limbs and parts of a Louſe, both internal and external. This example, by which I propoſe to illuſtrate the firſt claſs of inſects, and the examples I ſhall give, in their due places, for the other three claſſes, will enable the reader to form a competent judgment of the changes, which all other inſects undergo, according to the different claſſes to which they belong. It muſt be allowed, however, that whatſoever pains we may take to arrange them, there will ſtill remain, even amongſt thoſe of the ſame claſs, very remarkable differences; and ſome of thoſe differences will be in the mutations they undergo. This will moſt clearly appear from our experiments relating to the fourth claſs, in the caſe of the worm-like Nymph of of the Aſilus Fly, and in the egg-like Nymph of the common Fly; between which there is no ſmall difference, though they belong to the ſame claſs, and are liable afterwards to the ſame changes. This accidental difference may alſo be ſeen on looking over the figures of animalcules, which I have given under each kind in the ſpecial hiſtories of the three other claſſes. It appears very ſtrikingly in the Cryſallides of Caterpillars, as they are exhibited in the deſigns of the indefatigable Goedaert; for though they all belong to the ſecond mode of our third claſs, yet one Chryſalis differs in many particulars from another: this difference is, however, far from being what is called eſſential, it only conſiſts in ſome part of the external forms.

From the firſt claſs of our changes, we ſhall now ſelect the Louſe as an example, and repreſent by figures, the changes which happen in its parts, till it comes to its full growth. The Libella, or Dragon Fly, will ſerve us for the ſecond claſs; and the Ant for the firſt mode of the third; the nocturnal Butterfly for the ſecond. Laſtly, we ſhall give the common Fly as a ſpecimen of the fourth claſs; and I ſhall afterwards illuſtrate theſe ſeveral changes by the accretion of the limbs in a Frog, and the budding out, or ſhooting, of the parts of a flower.

Though the foregoing natural changes, and the compariſons of others which will be made in treating of them, may be thought ſufficient for giving a clear idea of the practices of the inſects contained under the four claſſes, into which I have arranged them, and of the differences between each claſs; nevertheleſs, I ſhall add to the firſt claſs, a ſeparate and ſatisfactory account of the manner wherein the parts of Snails grow and are changed. I ſhall do the ſame by the Ephemeron, or Fly of one day, in the ſecond claſs. In the third claſs I ſhall exhibit, according to the firſt mode, all the changes of the Bee, with a complete diſſection of that inſect and the horned Beetle; and the ſame both in deſcriptions and by figures of the common day Butterfly, according to the ſecond mode of the third claſs. Laſtly, I ſhall give in the fourth claſs an account of all the changes which the Aſilus, or Gad Fly is ſubject to, and illuſtrate them with plates. I ſhall, beſides theſe, inſert various other hiſtories, all which will not only throw a light upon each other, and repreſent clearly and diſtinctly the changes of the four claſſes in the exact manner wherein they happen, but, what is much more advantageous in this kind of ſtudy, they will diſplay ſuch miracles of wiſdom, power, and goodneſs in the great Creator, as cannot fail powerfully to incite us to love and adore him. This, indeed, is the great purpoſe I propoſe to myſelf in my inquiries concerning theſe natural mutations.

To ſet forth clearly and diſtinctly the orders of the tranſmutations in the Louſe and Dragon Fly, the nocturnal Butterfly, and common Fly, and to exhibit more plainly the changes of each of them; as alſo that I may be able to demonſtrate thoſe, wherein the orders of the changes agree or diſagree among themſelves: I ſhall uſe the ſame number, and obſerve the ſame rule in explaining the five reſpective figures. For though there be not the ſame neceſſity to proceed in the ſame manner in ſetting forth all the figures of the changes and accretions obſerveable in thoſe inſects; as for example in the change of the Louſe, which is only a ſimple augmentation; yet, ſince we ſee five diſtinct changes in the Libella, or Dragon Fly, and other inſects, whoſe figures we exhibit before they attain their full age, and are rendered fit for generation, we have been, as it were, obliged to treat the Louſe in the ſame regular manner, in order to render the whole more exact and uniform, as we have before done in comparing the Frog with the flower or vegetable increaſe.

We have not obſerved that method alſo in the particular hiſtories of Bees and the reſt, as well becauſe their anatomy are ſubjoined to thoſe accounts, as that the claſſes we have advanced, ſeemed calculated to exhibit a certain general rule, whereby all the changes of inſects produced by nature may be tried and examined.

Finally, every thing marked in numbers in the explanations of the figures, is delineated in its natural bigneſs; but the Animalcules, to whoſe figures the numbers 1, 2, 3, &c. are affixed, are repreſented as they are magnified by the microſcope; while ſome others that are characterized by 1, 2, 3, are repreſented to the life. This has appeared to me the proper method of proceeding in this affair, for two reaſons; firſt, leſt the order of the number ſhould be broke by increaſing or diminiſhing the figure; ſecondly, becauſe ſome of theſe inſects are ſo large of themſelves, that there is no need of a microſcope to delineate them.

To follow nature as near as we could, we have put the white animalcules, or little animals of our four claſſes on a black ground, which we have not done with reſpect to the other coloured ones. This appeared the more neceſſary, as Goedaert repreſented a briſtly Caterpillar, the figure whereof we have in one of our tables, without any hair at all, which error was probably owing to his not laying it on a black ground, whence its white hairs were not diſcernible.

To make the rule of our four claſſes the ſtronger, we have alſo been careful to ſelect animalcules that are ſo well known, that there is no neceſſity to illuminate them with colours. And we are confident, that our figures are ſo accurately executed, that it would be unpardonable to daub them with paint. We come now to treat of the Louſe, which I now intend to do, comprehending the whole doctrine concerning it in the form of a letter.

TO THE MOST ILLUSTRIOUS

Mr. THEVENOT,

Formerly embaſſador from the king of FRANCE to the republick of GENOA.

Most illustrious Sir,

THE omnipotent finger of God is preſented to you in the following ſheets, in the anatomy of a vulgar and loathed inſect, the Louſe; wherein you will indeed find miracles heaped on miracles, and will be amazed at the wiſdom of God, moſt clearly manifeſted in a minute point. Let the world admire the maſterly ſtrokes of Apelles: here you will find the complete fabrick of the viſcera of all the animals in the world, formed with the moſt exquiſite workmanſhip, and abridged, as it were, in a particle of a line in meaſure. What mortal, illuſtrious ſir, can attain to this by reaſon? what other hand, but that of God, can inveſtigate and frame ſuch things? The ſpirit and grace of God, which he beſtowed on mankind, has rendered ſome capable of ſearching into ſuch ſublime miracles and ſecrets, and to lay them open to the view of others. Though the Ægyptian Magi could imitate the other miracles which God performed by Moſes, they were not able to produce theſe animalcules by their magick art, as the ſacred writings teſtify. * "Aaron "ſtretched out his hand with his rod, and "ſmote the duſt of the earth, and it became "lice in man and in beaſt; the magicians did "ſo with their inchantments to bring forth "lice, but they could not; then the magicians "ſaid to Pharoah, this is the finger of God." I cannot ſo properly, illuſtrious ſir, offer theſe obſervations to any other as to you, ſince I know no other that ſets a due value on ſuch things, according to their dignity.

The EXTERNAL PARTS.

BEFORE I exhibit the internal parts viſible in this ſmall and deſpiſed animal, I ſhall deſcribe its external parts, and ſhall ſhew every thing remarkable in the head, thorax and abdomen.

The ſhape of the fore part of the head is ſomewhat oblong, that of the hind part ſomewhat round; the ſkin is hard, and being ſtretched, is tranſparent like parchment, and has here and there briſtly hairs. At the extremity of the fore part is the proboſcis, or ſucker, Tab. I. fig. IV. *a*. ſeldom viſible, ſince it is always drawn to the inſide; I ſhall therefore deſcribe it when I come to the throat and ſtomach. On each ſide of the head are the antennæ or horns *bb*, which are alſo covered with a ſkin like parchment. Each of theſe is divided into five joints, elegantly covered with briſtly hair, and ſeveral white veſſels are ſeen through theſe horns. Behind theſe are the eyes *cc*, which ſeem to want thoſe hexagonal diviſions obſervable in other inſects, and they appear to be incompaſſed with ſome few hairs.

The neck is very ſhort, the breaſt is divided, as it were, into three parts; in the middle of which, on the back ſide, appears, as it were, a ſmall ſhield. On each ſide are placed ſix legs *dd*, each of which conſiſts of ſix joints, ſome larger than others: they are very delicately adorned with briſtly hairs, and many whitiſh veſſels are ſeen through them. The ends of their legs are armed with a ſmaller and larger ruddy and pellucid claws *ee*, ſerving theſe inſects in place of a finger and thumb; for by the former they take hold of a perſon's hair, and by the latter, they are able to aſcend and run nimbly. Under, at, and upon the breaſt, where it is joined to the legs, and, as it were in the very center of it, there appears a ſhort whitiſh groove or channel, which is conſpicuous through the middle of the abdomen, appears of a browniſh colour, fig. v. vi. and has very ſtrong motions. On either ſide of this groove or channel are two bright little parts, like the larger before deſcribed, whoſe appendages they are, and which riſe conſiderably on the inſide of the breaſt, and are there alſo tranſparent.

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* Exod. viii. 17, 18.

The abdomen is divided into ſix parts, and at the end of it, on the under part, the body terminates as it were in a cloven tail. Beſides theſe in the middle of the lower part of the belly, there is to be obſerved a whitiſh ſpot like a point, which is alſo tranſparent, and moves diſtinctly up and down. On the ſides and extremities of the belly, which is all over hairy, are obſerved ſome pellucid, ruddy, little bodies; and over the whole belly, a great number of white veſſels are viſible, fig. iv. *gg*. The like are diſcernable in the back and breaſt. The ſkin of the abdomen is made like the ends of our fingers, conſiſting of ſmall grooves, but this ſtructure does not hold through the whole, and not at all at the extremities of the abdomen; for there, as well as in the whole body, it is ſomewhat firm, like clear parchment, and when roughly preſſed, it makes a noiſe and breaks.

The anatomy of the INTERNAL PARTS.

TO obtain a perfect knowledge of all thoſe parts, which I have hitherto mentioned in general, there is no other way but to diſſect the creature. I ſhall therefore now give an exact deſcription of all the minutiæ relating to the internal parts; for by this means we ſhall have a complete idea of the external alſo.

If we begin the diſſection in the upper part of the abdomen, and cautiouſly open the ſkin there, blood immediately iſſues from the wound, and this being received into a ſmall glaſs tube, Tab. II. fig. i. *aa*, and viewed with a powerful microſcope, is ſeen to conſiſt of tranſparent globules, as cows milk: the ſame has been likewiſe diſcovered in the human blood for ſeveral years; it is found to conſiſt of ruddy globules ſwimming in a clear liquor.

It is, however, a matter of doubt, whether the blood in its veſſels has any globules, for when drawn from them it may eaſily acquire that figure; this may at leaſt be aſſerted of the ruddy part of the blood. I have therefore often reſolved to put a ſmall glaſs tube into the artery of a dog, and with a microſcope to view the flowing blood. For thus, by analogy, it may be poſſible to determine with ſome certainty, whether the human blood, before it is taken out of its veſſels, contain any globules. I am the more in doubt concerning this matter, becauſe there are veſſels diſcovered in the body, which appear much finer than the globules themſelves viſible in the blood. By this means alſo may be known the true difference between the arterial and venal blood; for in the latter only, I have hitherto obſerved theſe globules, having never examined the former: Nor ſhall I poſitively aſſert, that there are originally globules in the Louſe's blood, for they may be eaſily formed by the intermixture of the blood with the fat, and ſome wounded particles of the viſcera or bowels, which conſiſt of a congeries or heap as it were, of globular parts; as I ſhall ſhew in its proper place. Wherefore, more time ought to be ſpent in this anatomy, than I can devote to it at preſent, being engaged in many other ſtudies.

Tab. II. fig. ii. Immediately under the ſkin are certain muſcular fibres, which move the annular diviſions of the abdomen. I have obſerved three diſtinct kinds of theſe muſcles, ſome a little broader *a*, others narrower *b*, and a third ſort with two bodies *c*. One may ſee that theſe muſcles extend themſelves from one annular diviſion to another, and that ſome are much ſhorter than others. This little animal is very full of muſcles, particularly at the extremities of the abdomen; ſince the motion is ſtrongeſt in that place, and the reſpiratory points or orifices for reſpiration are placed there, by the aſſiſtance of which the Louſe takes in the air, and by a manifeſt act of inſpiration and expiration, draws it into the body, and again diſcharges it. When theſe muſcles are drawn from the body, they ſeem as if they conſiſted of but one fibre, but if they are dried upon a thin and clear glaſs, and waſhed with ſpirit of wine, which takes off the impure fat that adheres to them, their fibres and joints appear diſtinctly to be made up of globules.

Under theſe muſcles the fat and the tracheæ, or air veſſels, come in view; nor could I ever hitherto diſcover any veſtige of a heart in this upper part of the abdomen, as is uſual in other inſects, wherein the heart is always placed in the upper part of the abdomen and back; but I found clearly by this diſſection, that the Louſe otherwiſe agrees in all its parts with other inſects, as will hereafter plainly appear; therefore I have more diligently ſought for the heart, but in vain: this may probably be owing to its extreme ſmallneſs, ſince it is very difficult to find it in the larger inſects, as in the Horſe-Fly. There is alſo another impediment, which is, the ſtrong and continual agitation of the ſtomach in this inſect, being hardly a moment at reſt, from which there ariſes an unavoidable inconvenience in inveſtigating the heart.

The particles which I take to be the fat of the Louſe, are for the moſt part very ſmall, but extremely numerous, though we may diſcover it in a larger ſpecies or kind of fat particles; the figure of the ſmalleſt kind of particles is uſually globular, but that of the greater is more irregular. They are of a clear tranſparent colour, like gelly, but all the other parts of this animal are not of that colour.

The ramifications of the trachea, aſpera arteria, or windpipe, conſtitute the principal part of this inſect; a very conſiderable number of them are found in the head, breaſt, belly, legs; nay, and in the antennæ or horns. We may likewiſe obſerve, that they are connected and ſupported by the fat, as I have found in other inſects: and theſe are the white veſſels which are ſeen through the tranſparent body, as I have obſerved in the hiſtory of the external parts. The reaſon that theſe pulmonary pipes are ſeen through the ſkin, is, that they are of a ſilver colour, or light bright mother of pearl, and therefore afford a very agreeable ſight, whilſt the animal lives. They conſtantly keep this colour, nor will they ever fade, for their ſtructure is ſuch, that they remain always open.

As to their compoſition, it conſiſts of a double matter; a part is compoſed of rings, which reſemble the cartilages of the trachea, or windpipe, in man. It appears very diſtinctly by the microſcope, that theſe rings often bend themſelves round, in order to form a cavity and open pipe, Tab. I. fig. VII. *a*; but this does not happen ſo often as in other inſects, becauſe the rings of the Louſe are ſhorter: they are alſo more curled and twined *b*, in likeneſs of a Serpent, and ſeem every where interrupted *c*. It may alſo be obſerved, that where the aſpera arteria, or wind-pipe, is divided into branches, there theſe rings are largeſt *d*, but they are afterwards inſenſibly divided into ſmaller *e*. The other part of theſe veſſels is membranaceous, and is ſituated in the interſtices of thoſe rings; and by its aſſiſtance the rings may conveniently bend and turn themſelves, as is known to happen, particularly in thoſe wonderful motions of the ſtomach, which is ſurrounded by a great number of air-pipes.

I have hitherto omitted examining whether theſe pulmonary, pipes within the body, likewiſe ſhed a little ſkin at the time the Louſe caſts its coat, as I have obſerved to have happened in the Bombyx, or Silkworm, and in almoſt all other inſects. However, the ſmaller theſe pulmonary pipes are, the fewer rings they have, until at length they appear like more membranaceous threads.

I may venture to affirm, that the pulmonary pipes cannot be more conveniently viewed in any ſpecies of animals that I have hitherto known, without diſſection; ſo that we cannot contemplate their ſituation and courſe, with greater admiration, in any animal than in the Louſe. But I have by me a very curious and familiar apparatus, by the aſſiſtance of which, I can at any time demonſtrate it with the greateſt certainty.

Tab. I. fig. IV. The orifices of the XIV pulmonary pipes are ſeen in the outward ſkin of the Louſe; one (1) of which is on either ſide of the breaſt; and on each ſide, on the extremities of the abdomen are placed ſix, 2, 4, 3, 5, 6, 7, which I exhibit in the figure in one ſide only. I have alſo thought I ſometimes ſaw one pair of air orifices between the ſecond and third pair of legs; however, I will not be poſitive in this matter.

Tab. I. fig. VIII. Theſe orifices are the reſpiratory points, one of which is ſituated on one ſide, between the firſt and ſecond pair of legs, and ſix on the extremity of the belly, 1, 2, 3, &c. theſe points ſwell a little there, like a ſmall nipple *aa*, and in their circumference, ſeem to have a ſlight rim or border, which appears ſomewhat ruddy and tranſparent as the place itſelf wherein they are fixed is alſo of a light red and bright colour; they are a little bent towards the inſide, and immediately after the tegument of the extremity of the abdomen ſwells out. All the points are like that which I have obſerved to be placed in the breaſt. *b*.

Tab. I. fig. IV. From every reſpiratory point there iſſues a branch of the trachea *bbb*, which ſoon after forms a viſible anaſtomaſis or inoſculation with ſome branch of the trachea, that proceeds from another point, and both cloſe into one canal: the ſame holds alſo in all the XIV apertures of the lungs; ſo that the air, which is drawn into the body by one reſpiratory point, may be ſpread through the whole. Nor is it there only that the pulmonary pipes unite, but this holds equally in thoſe which are in the back, belly, and breaſt; which laſt is diſtinguiſhed by three manifeſt ramifications that are joined together underneath. This matter hath been already elegantly delineated by doctor Hooke, in his incomparable Micrography; however, he could have no knowledge of theſe ramifications by any other means, but that they appear viſible through the body.

I am further inſtructed by the diſſection, that the pulmonary pipes may be diſcovered not only in the head, breaſt and abdomen, but they reach alſo to the inteſtines, the ovary, ſpinal marrow, brain, and, in fine, to all the internal parts of the body of this animal; all which, as I have diſtinctly ſeen, ſo I can demonſtrate them to others, with the aſſiſtance of certain experiments which God enabled me to invent in the ſtudy of anatomy, that the miracles of his works might be known: for we have not even the leaſt thing from ourſelves, for it is God that giveth us ingenuity.

Theſe things being well underſtood, I might proceed to deſcribe the other parts; as firſt, the ovary, which appears next after the former, being a part placed upon the ſtomach itſelf: but ſince method requires us to treat, before theſe, of thoſe parts which aſſiſt digeſtion, and tend to the nouriſhment and preſervation of the body, and afterwards of thoſe which ſerve for generation. I ſhall now deſcribe the proboſcis, or ſucker, the throat, ſtomach, inteſtines, and other adjacent parts. I ſhall after theſe treat of the ovary, brain and nerves, and then add ſomething concerning the outward ſkin, with which I ſhall conclude this anatomical deſcription.

The Louſe has neither beak, teeth, nor any kind of mouth, as doctor Hooke deſcribed it, for the entrance into the gullet is abſolutely cloſed: in the place of all theſe, it has a proboſcis or trunk, or, as it may be otherwiſe called, a pointed and hollow aculeus or ſucker, with which it pierces the ſkin, and ſucks the human blood, taking it for its food into the body. But this proboſcis cannot be ſhewn, on account of its extreme ſmallneſs; nor can it be diſtinguiſhed, unleſs a perſon happens to ſee it by chance.

At the extreme point of the head, when preſſed out artificially, and with a particular attention, there appears an obtuſe prominence, Tab. II. fig. III. *a.* which being hollow in the middle of the inſide, bends back into itſelf, and goes into the body, but has no aperture or opening. From this the proboſcis *b*, or ſucker, is obſerved ſometimes to proceed, and wherefore this part is, as it were, the ſheath or caſe of it, wherein it is laid up.

I cannot illuſtrate this ſtructure or machinery by a more proper example, than by that of the horn of a ſnail, which is likewiſe turned into itſelf on the inſide, and is again ſtretched out, but there is no perforation: wherefore, if the proboſcis or ſucker was placed at the end of it in this inſect, inſtead of the real eye which we ſee in the ſnail; one might in ſome meaſure form an idea how the proboſcis, or ſucker, is wrought in this inſect, and worked up with admirable art by the ſupreme architect of the univerſe.

If the whole little ſheath or caſe be afterwards examined, Tab. II. fig. IV. *c.* it is obſervable, that the upper end of it is thicker than the lower, and is ſwollen like a muſhroom; ſo that it appears from hence, that the little foot on which it ſtands is ſmaller than its top. When one preſſes the proboſcis, or ſucker, and its ſheath on the outſide, we ſhall find that the end of the latter is abſolutely blunt and reſembles the head of a pollard willow tree, having all its branches cut off; we ſee alſo that there are here and there certain pointed parts or claws *d* in it, which, as well as the ſheath, and the proboſcis or ſucker, are of a light brown colour, and are tranſparent. I ſhall preſently ſhew the uſe of theſe claws; there is alſo a crooked proboſcis or ſucker *e* in the middle of them. The outward ſkin of the ſheath which is annexed to the proboſcis, and from which its head is prominent, is of the ſame texture with the reſt of the ſkin that covers the Louſe; for it conſiſts of grooves and pellucid globules, as I ſhall explain hereafter, when I treat of the ſkin.

If we examine that part of a Louſe's head at the time when it is ſeeking out ſome pore of ſweat in the hand, wherein to fix its proboſcis or ſucker, a ſmall line of a pale brown colour is then preſented to us, which appears viſible through the head, and has its fore part more deeply coloured. This little line is nothing elſe but the ſheath itſelf, with the proboſcis hidden in the inſide.

But before I explain the uſe of this proboſcis or ſucker, and its manner of riſing, it ſeems neceſſary to deſcribe the figure, ſituation, colour, texture and motion of the gullet, ſtomach, and inteſtines: for thus the method whereby the proboſcis performs its ſuction, will be more eaſily underſtood. The œſophagus or throat is a very ſmall canal, fig. III. *f*, which one cannot ſee at any other time, but when the blood aſcends through the proboſcis or ſucker into the mouth, and paſſes through this into the ſtomach. It is ſituated a little behind the eyes, and ſeems to be carried up above the brain: the reaſon that I think ſo is, becauſe it appears there very clearly at the time of ſuction; ſo that probably it runs immediately under the ſkin of the head. In the neck it is ſomewhat enlarged *g*, and afterwards it grows ſmall again in the back *h*, untill it terminates in the ſtomach, near which I have obſerved it, like a very ſmall, clear, and tranſparent thread, wherein a perſon that diſſects it ſometimes obſerves blood, and ſome other ſubſtance, which appears like the contents of the ſtomach. I diſcovered the whole gullet, in the action of ſucking, as before deſcribed; for it is a very difficult matter to diſcover it in any other manner, becauſe in the upper part of the back, and alſo in the head and neck, it is very ſtrongly connected with the adjacent parts.

The ſtomach, fig. III. *ii*, is lodged partly in the breaſt and back, but the greateſt portion of it is in the abdomen. When ſwollen with blood it appears of a dark brown colour, which is viſible through the ſkin, and is either a faint red, or a full or bright brown, as the contents of the ſtomach are more or leſs changed. Where the ſtomach joins the breaſt above, its figure reſembles a fork with two teeth; theſe are two hidden appendages of *kk* the ſtomach, which go deep into the breaſt, and on either ſide near the gullet and ſpinal marrow, and reach to the firſt pair of legs. Theſe are thoſe two blackiſh, tranſparent and coloured parts, which I have mentioned in general in the hiſtory of the external parts.

The part of the ſtomach connected with the abdomen deſerves particular conſideration; it is formed like an oblong bag, which is here and there continually contracted and again extended. When it is empty, it is colourleſs, and the ſtomach and its appendages are tranſparent. But as the ſtomach fills, the colour is ſeen plainly through the outward ſkin. It manifeſtly conſiſts of two coats, the outward is thicker, the inner very thin, as it is in all inſects. Nay, it is probable that it has three coats, and that the third is muſcular.

The outward coat of the ſtomach is furniſhed with ſo great a number of pulmonary *llll* pipes as can hardly be expreſſed in words. The larger branches are very conſpicuous in it, but the ſmalleſt cannot be diſcovered, except by the aſſiſtance of the beſt microſcopes. On the contrary, the inward coat is very thin; the third, which, I ſuppoſe to be ſituated between the two former, comprehends without doubt, the muſcular fibres of the ſtomach, by the help of which it performs its wonderful motions. The coats of the ſtomach, eſpecially the outmoſt, appear to conſiſt of very many globular little grains, which are very irregular in form; but whether theſe little grains properly belong to the texture of the ſtomach, or whether they are rather particles of fat, which cover the ſtomach, whereby the pulmonary pipes are gently moved, I could not well diſcern; only this I know, that the greateſt part of them, when often touched, retire from the ſtomach.

Underneath, in the abdomen, on a little riſing or prominence, nearly in the middle of the ſtomach, there is ſeen a certain little part *m*, which doctor Hooke apprehends may be the liver; but I ſhould rather take it to be the pancreas, or ſweet-bread, though there want ſufficient arguments to prove it. Its colour is not properly whitiſh, but ſomewhat inclining to yellow; and it is ſo ſtrongly connected with the ſtomach, that it cannot be eaſily ſeparated from it. If this be laid before the microſcope, it may eaſily be divided into many little grains like glands, but theſe are not very tranſparent. When it is accurately viewed by the microſcope, the pulmonary pipes alſo appear in it. The ſubſtance of this little part is more firm than that of the reſt, for when it is extracted from the body and dried, it is but little diminiſhed. It is of a very irregular figure, and is formed divers ways in almoſt every Louſe, being ſometimes greater and ſometimes leſs; but it is always finiſhed in the ſame general manner, by reaſon of its bendings and ſituation over the ſtomach, as is evident from the five different figures of theſe little parts, which I have delineated to the life from the microſcope, in fig. v. 1, 2, 3, 4, 5, of Tab. II.

At the lower region of the ſtomach is ſeen the pylorus, fig. III. *n*. and immediately from this, the inteſtinum tenue or ſmall gut *oo*, which is extended on each ſide, and formed like the ſtomach: this is alſo provided with a great many pulmonary pipes. At the end of this ſmall gut, which is for the greateſt part bent in a ſerpentine manner, or like the letter S, are diſcovered four ſmall veſſels *pppp*, which the ſagacious and excellent anatomiſt Marcellus Malpighius, has called the ſwollen veſſels in Silk-Worms; but theſe are ſtraighter and leſs inflected in the Louſe; they are conſiderably long, and of the ſame texture with the inteſtines. Theſe four little veſſels are properly four inteſtina cæca, or blind guts, which I have found in all inſects; wherefore, by inference, I call them here by this name, though I never have had the fortune to ſee their extremities. They open into the inteſtine, from whence they ariſe at the place juſt mentioned. After theſe appears the little inteſtine colon *q*, and at the end of that, there is a manifeſt dilatation or extenſion *rr*, which is the cloaca, or place where the excrements acquire their figure; for they are very irregular, and not like thoſe of other inſects, which are uſually formed in a ſingular and regular manner. Within this dilatation appears the inteſtinum rectum *s*, which ſhews its aperture, as the anus ſituated upon the belly between the diviſion of the tail *t*; and juſt under this the skin is very briſtly.

As to the motion of the ſtomach, it is truly admirable; inſomuch that one might ſuppoſe it an animal within an animal, by reaſon of the ſtrong agitations, contractions, dilatations, corrugations and expanſions, all which belong to it, and ſtrike one with amazement, the whole being plainly ſeen through the body. Theſe appear plainly at the time when the ſtomach is full of food, but they are beſt of all ſeen, when the blood paſſes into it at the time of ſucking; for then it is ſometimes obſerved, that the remainder of the old aliment is mixed with the new, and is ſhaken and agitated up and down, and on every ſide, in the ſtomach. This may be ſeen the more diſtinctly, as the colour of the contents is more dark.

Hence one may eaſily conceive what ſtrange changes and emotions the pulmonary pipes on the ſtomach undergo at that time, and after what various ways the air contained in them is preſſed, moved, propelled, and ſo purified; changed from its firſt nature, and rarified within the creature. But who can diſcover, by the moſt diligent reſearches, the uſe of the air in that place? ſurely no one. Yet very wonderful motions are obſerved on this occaſion, particularly in that little part which I called the pancreas or ſweet-bread; for this being connected with the ſtomach, muſt obey all its motions. That any perſon may form to himſelf an idea of the motion of the ſtomach, I have drawn three figures of it. When contracted, it is ſeen as at number 3, fig. VI. Number 2 ſhews how its contractions are changed, and after what manner it dilates, is apparent from number 1. Theſe motions are continually repeated by turns, and undergo an infinite number of variations.

As to the method whereby the Louſe ſucks the blood, and conveys that nouriſhment into the ſtomach, it is performed thus, by the aſſiſtance of the proboſcis, and its aculeus or point. Firſt, if the Louſe has abſtained from food two or three days, it becomes very hungry, which is diſcoverable from the empty ſtomach, and becauſe the creature is then wholly tranſparent; in this caſe, immediately as ſoon as he is placed on the hand, he ſeeks for food, which he will the ſooner and more readily find, if the hand be firſt rubbed until it grows red.

Then the Louſe turns his head, which lies between the two fore legs, to the ſkin, and diligently ſearches for ſome pore of ſweat: when he finds it, he fixes his aculeus, or ſucker, therein; a little after this, the blood is obſerved, through the microſcope, to aſcend to the head, in a very rapid, and, as it were, frightful ſtream.

The Louſe has at that time matter enough to feed on in any poſture, for if it finds any hairs on the hand, by which it does not deſire to deſcend, it ſtays in that poſture, and ſucks with its head down, and its tail elevated. I have likewiſe obſerved that it ſometimes ſucked with its belly upward, that is, when the hair it took hold of was bent down; and then the motion of the ſtomach, and pancreas, or ſweet bread, might be ſeen moſt beautifully by the help of a microſcope.

But I ſhould think the principal uſe of the claws, which I have deſcribed to be ſituated at the end of the ſheath or caſe of the aculeus or ſucker, is to aſſiſt the creature in ſucking, and that the aculeus ſerves for this purpoſe; for whilſt theſe are ſtrongly fixed in the ſuperficies of the inner ſkin, and in the extremities of the pores, they enable the Louſe to uſe its aculeus the more freely, and to move it at diſcretion, when the end of its ſheath is placed firm and immovable.

Sometimes, whilſt the Louſe was ſucking, I have ſtrongly pulled the ſkin of my hand aſide, that by this means the ſheath, or rather its claws, together with the aculeus or ſucker, might be bound faſt in the ſkin, and the Louſe could not diſengage itſelf. This affords indeed a very agreeable ſight. This I did with a deſign, that if I could thruſt the Louſe out of its place, I might the more plainly ſee the aculeus: but I could never accompliſh my deſire in this particular, though I had then almoſt wiſhed to have three hands, that I might the better find what I wanted. There are ſome ſpeculations and reſearches in anatomy that will not bear writing, ſince they almoſt diſtract the mind.

When the Louſe is employed in ſucking, a very ſmall rivulet, Fig. III. *u* of blood immediately appears behind the aculeus or ſucker, which is ſeen through the tranſparent head. Between and before its eyes, on the middle of the head, there is obſerved alſo a conſiderable dilatation *x*, for the jaws are there remarkably expanded, by the blood continually aſcending. Theſe parts are ſo ſwiftly contracted again, that there ſcarce remains the leaſt ſign of blood after a moment, and both are performed with ſuch velocity, that the dilatation can hardly be diſtinguiſhed from the contraction; wherefore I do not know how to explain this matter more properly, than by the ſudden oſcillation of the pendulum of a clock. Behind the eyes, a ſmall rivulet of blood is likewiſe obſerved to run down within the head: this paſſage may be properly called the œſophagus or gullet, fig. III. *f*, which lies behind the jaws, and grows wide again in the Louſe's neck as has been ſhewn before *g*. I have choſen to exhibit all theſe as one continued canal, that my deſcription may be the more clear.

After the blood has aſcended to the jaws, and comes to the gullet, we obſerve that it is immediately conveyed to the ſtomach, and that the bifurcated appendages, as well as the ſtomach itſelf, are at once filled with it. The motions of the ſtomach are then remarkably increaſed, its muſcular parts being diſtended; for as theſe muſcular parts are then ſtretched, they have an opportunity of contracting themſelves again. Wherefore it is immediately obſerved, that the excrements in the large guts begin likewiſe to move; nay, it uſually happens that the Louſe diſcharges them during the ſucking.

The food being thus received into the ſtomach, is agitated about in a wonderful manner; it is moved up and down, and by contractions and dilatations, which are not to be deſcribed, then performed by the ſtomach, is, as it were ſifted. After this, it is ſeen, that the contents firſt begin to divide into parts in the back or hinder portion of the ſtomach, and they then appear like raiſins preſerved in jars, and are thus diſtributed through the body. However, this is a falſe appearance; it ariſes from hence, that the ſkin being divided into many grooves, is not equally tranſparent every where, and that ſome difference is in this reſpect ſeen through it, becauſe the grooves are not equally tranſparent with the intermediate parts. Nay, the particles of the internal fat not being uniformly viſible through the ſkin, and obſcuring the brightneſs of the ſkin, conduce likewiſe to deceive the ſight, as if the retreating blood entered into many peculiar veſſels. To this may be added, that the blood has not at that time a homogeneous or equal colour, for its parts ſeparate from each other. From theſe appearances, before I had accurately examined things, I thought that the blood was diſtributed out of the ſtomach, through various veſſels, into the other parts of the body; but I afterwards obſerved that this phenomenon aroſe, as well from the blood itſelf, as from the different colours of the parts through which it was ſeen, and which I then took to be veſſels. Perhaps others, eſpecially doctor Hooke, who firſt prejudiced me in favour of this opinion, have ſplit on the ſame rock. I have not as yet made this experiment in the ſmalleſt Lice, in which more peculiarities may probably be ſeen, than in the larger kind.

I have likewiſe reſolved to receive the blood, when changed in the ſtomach, into a glaſs tube, and then to view it in the open air, or in ſome dark place by candle light; but this I have not hitherto done, being hindered from making this, as well as many other experiments which I had a mind to try. In ſome hours after feeding, the contents of the ſtomach are obſerved to become inſenſibly more brown or blackiſh, and to diminiſh ſlowly: wherefore the inteſtines are afterwards ſeen to be more and more diſtended with excrements, which ſometimes lie in them regularly divided, as it were, into globules. The reaſon of this is, that the inteſtines do not, at one and the ſame time, contract themſelves about the fæces, and therefore they caſt or extrude them out of the body at different times. I have already treated of the muſcles of the abdomen in this inſect, I ſhall now proceed to the parts of the breaſt.

In this part, and in the back, are ſeen ſeveral muſcles, which move the legs and head; and herein are alſo viſible the appendages of the ſtomach, and a great number of pulmonary pipes and particles of fat. In the ſame view is alſo ſeen the gullet and ſpinal marrow, together with the nerves ariſing from thence, of which I ſhall now ſpeak diſtinctly.

In the middle of the back is ſeen a certain tendenous point, under the ſmall ſhield there ſituated, where the ſkin does not appear to be ſo tranſparent as in the reſt of the body. This ſhield ſeems there to be hollow, being thruſt down into a little pit. At this point almoſt all the muſcular fibres are ſeen to concur, and their motion and contraction are here very viſible. As to the appendages of the ſtomach, and other parts of the breaſt and back, we have before treated of them at large.

The ſpinal marrow is properly ſituated in the breaſt, and therein reaches to the inſertion of the laſt pair of legs. When this is diſcovered, it is eaſy to judge what that ſhort whitiſh groove is, which appears through the breaſt, between the appendages of the ſtomach; for theſe appendages are placed on both ſides of the ſpinal marrow.

The ſtructure of the ſpinal marrow itſelf, does not differ much from that found in the Worm, from which the Scarabæus Naſicornis, or Horned Beetle, by the ancients conſecrated to Mercury, is produced, as is manifeſt from the hiſtory and figures of the latter. It conſiſts of three remarkable ſwellings, expanſions or dilatations, fig. VII. *aaa*, from which, on either ſide, we obſerve three nerves *bbb* to ariſe, which reach to the muſcles of the ſix legs; but underneath, or in the hinder part of it, I diſtinguiſhed ſix nerves *cc* iſſuing, which doubtleſs are diſtributed through the reſt of the viſcera, to give them life, ſenſe and motion. The loweſt of thoſe little knots, whereof the ſpinal marrow is compoſed, is formed in a different manner from the upper ones, which are alike.

The membrane which covers the marrow is interwoven with a great many pulmonary pipes, and ſeems to be compoſed of irregular and globular little parts *dd*, in the ſame manner as we have ſhewn in reſpect of the coat of the ſtomach: and this texture, together with the great number of pulmonary pipes belonging to the part, afford a very agreeable ſight in the living inſect.

I could diſcover no fibres in the nerves, which ariſe from the poſterior part of the marrow, though I viewed them freſh with the microſcope; they ſeemed indeed to be made up of a homogeneous, bright and tranſparent matter, and at their ſides were hung a great many pulmonary pipes, with particles of fat.

The origin of the marrow, where it is connected with the brain, is ſeen like a fine thread *e*. But in all other inſects this beginning of the marrow is perforated, and through its aperture or cavity the gullet paſſes.

The brain of the Louſe is ſhaped like a pear *ff*, and is divided into a right and left part. The dura mater, ſurrounding it, is formed like the membrane that covers the marrow, and is provided with pulmonary pipes and particles of fat *gg*. I can very eaſily at any time ſhew the marrow, but the demonſtration of the brain muſt be obtained rather by chance, than with any premeditated deſign or art; it is clearly ſeen when by any accident it happens to be ſtript of the parts wherewith it is covered.

The optic nerves *hh* are ſhort, and the eyes *ii*, which are connected to them, are ſo ſmall, that I could not diſſect them to my ſatisfaction; as well becauſe this operation is but aukwardly performed under miſcroſcopes, which magnify objects ſo much, that all inſtruments are too coarſe for this purpoſe. Thus much, however, I diſtinctly ſaw, that this black part in the eyes might be ſeparated or lifted up from them; which part in other inſects I call the tunica uvea, not being ſituated on the bottom, but on the ſuperficies of the eye; after this appears the tunica cornea; this ſeemed divided as it were into hexagons, as it is in other inſects, though the other was not: but that I would not affirm for certain, for we are not to ſuppoſe or imagine, but to purſue by our ſenſes, and diſcover the actions and productions of nature. This opinion, however, does not pleaſe ſome anatomiſts, who therefore eſteem all comments on the brain merely as ingenious fancies. The younger Bartholinus, who, ſpeaking of the fiction that ſilkworms had no brain, expreſſes himſelf thus: "Behold, how many are pleaſed "with their own blindneſs! who, although "they are blind, and ſhall for ever remain ſo, "yet cry aloud they can ſee, ſince theſe their "contemptible works, which ought to be re-"moved from their eyes, and buried in obli-"vion, are laſting monuments of their cloudy "arrogance; for by this means they might "afterwards ſeek for the light of truth."

Whether Lice are diſtinguiſhed by the parts of generation, into males and females, as other inſects are, I could not diſcover. Heretofore, indeed, I had ſometime remarked that Lice get upon each other; but this I could not obſerve while employed in this diſſection. I found an ovary in every one of forty, which I diſſected; this almoſt inclined me to think that theſe little animals are Hermaphrodites; and perhaps they really have in each animal a penis and an ovary together, in the ſame body, as I have found in ſnails. Whether indeed it be ſo, is ſtill a ſecret to me, for though I ſaw the ovary very diſtinctly, I could diſcover no penis, notwithſtanding the great hopes I had of finding it, from having obſerved that all kinds of inſects have very large organs of generation.

The ovary is extended through the whole cavity of the abdomen, ſo that with its appendages it reaches even to the breaſt. It has an opening diſtinct from the end of the inteſtines, for as the upper part of the fundament is placed in the diviſion of the tail, in which the abdomen ends; ſo on the contrary the vagina or mouth of the ovary opens into the lower part of the abdomen, where the body is divided as it were into two parts, Tab. II. fig. VIII. as may be ſeen in doctor Hooke's figure. The ends or extreme appendages of the oviduct or egg-paſſage are like two tubes *bbbb*, naturally joined in one point; this I have ſhewn in the figure by one ſide. In the oviduct *c* are ſeen at once perfect eggs *d*, and their rudiments *e* or principles; ſo that in one ovary I have counted ten larger and forty four ſmaller eggs, together making fifty-four. In the uterus I ſaw one perfect egg, which was fallen down ready for birth; at that time theſe little eggs are called Nits. In my figure of the ovary there are fifty-one eggs.

The ovary is double *ff* in all Lice, and every part of it is ſubdivided into five oviducts *gg*, which on each ſide end in one common canal; next comes in ſight the uterus *h*, in which the egg *i* acquires its full perfection. Where the uterus ends, is ſeen a ſacculus or bag full of a glutinous matter *kk*, opening in that part into the uterus; this is deſigned for faſtening the eggs, whilſt they are laying; the ſame may be likewiſe obſerved in many other inſects, and particularly in Bees. I muſt acknowledge that I have not ſeen the glutinous matter contained in this bag; but I infer, from the ſituation and ſtructure of the part, that the bag was deſigned for keeping ſuch a ſubſtance. After this appears the neck of the uterus *l*, and therein is a ſmall dilatation or expanſion; by means of which, the ovary immediately opens itſelf into the outward womb, as may be ſeen at the letters *aa*.

The oviducts embrace the eggs ſo cloſely, that ſcarce any difference is obſerved between them *m*, nor can we ſeparate the oviducts from the eggs, without great labour; when we do this, a great many bags of fat iſſue from thence, which obſtruct the ſight. It therefore has appeared to me, that the ſtructure of the oviduct is the ſame with that of the ſtomach and inteſtines; though the texture of this part is nevertheleſs more delicate, and that the globular particles proceed from thence with greater eaſe, than in the other viſcera. The oviducts are provided with many pulmonary pipes *n*, of which, as we have already obſerved, this little animal has a very large number, though no bigger than a point; its ſtructure and viſcera, which excel all human art, the greateſt geniuſes ought to be amazed at, as I have here, though briefly, yet clearly, explained and demonſtrated. I am perſuaded that I might make many more diſcoveries in it, if I had more time for that purpoſe, ſince I have completed this diſſection, and diſcovered theſe remarkable miracles in this microcoſm or little world, in the ſpace of ſix days. If the learned Daniel Heinſius had ſearched for theſe things in nature herſelf, and not in his own fancy, and in books, he would not have written ſo poor an encomium on this inſect.

As to the ſtructure of the external skin of the Louſe, it affords many particulars worthy of obſervation, nor is there any thing that bears a greater likeneſs to it, than ſtiff and tranſparent parchment: it is in ſeveral places marked with ſmall grooves or channels, in the ſame manner as the ends of our fingers; which, when viewed with the beſt microſcopes, really ſeem to be ſo many diviſions of pulmonary pipes. But the lens of the microſcope muſt, for this purpoſe, be carefully managed, for as it is turned one way or another, different things are ſeen: one cannot bring the lens nearer, or remove it further, by the leaſt diſtance, but ſomething is immediately perceived by the ſight, which was not obſerved before. Globular particles, fig. IX. *a*, ſometimes appear in the place of channels, or oblong pipes *bb*, though the eye is always fixed on the ſame part; then between the grooves themſelves, where the skin is ſimply membranaceous, globular particles *c* are likewiſe obſerved. In other places, as in the extremities of the abdomen, the ſtructure of the skin is different, for there it ſeems to be compoſed as it were of irregular ſquares; Tab. II. fig. x. *d*, wherein circular grooves *e* may be ſeen in one part; in another globules *f*; in a third, both globules and grooves *g*, nay ſometimes the plain tranſparent skin only is ſeen full of points *hh*; all which, as we have before obſerved of the oblong grooves, are repreſented according to the tranſparency of the parts, which have not been yet totally ſeparated from the inner ſurface of the skin; or juſt as the microſcope is moved, ſomewhat nearer to, or further from the skin.

Concluſion to Mr. THEVENOT.

All theſe things, moſt illuſtrious ſir, while I viewed them, I have carefully delineated with my own hand, as you may ſee by the figures annexed. I ſhall now leave you to judge, whether chance, by any right, can claim even the leaſt part in the moſt artful ſtructure of the ſmall point of the univerſe, which is here exhibited; ſince ſo many and ſuch different miracles jointly proclaim in it the divine omnipotence. Wherefore though this animal is of no advantage to the body, yet it is able to raiſe our thoughts to God; ſo that by ſeriouſly contemplating the divine Majeſty, and the glittering rays of his miracles, in this little animal, we may, with the moſt ſubmiſſive humility, change and contract our vain pride into as ſmall a point.

Then we ſhall obſerve the finger of God in theſe things, and ſhall obtain an effect, which none of the ſorcerers can imitate, or reduce into act: for the moſt ſmall and humble may drive away the devil, and rob him of his ſtrength.

The miracles of God are magnificent in every thing he has created; and even the ſmalleſt of them are the hoſt of the Lord of Iſrael; wherewith he does ſervice to his people by chaſtiſing them, when their ſins are grown to an height; that they may repent and acknowledge the ſupreme hand, which puniſhes our offences, as we are taught at large in the ſacred writings. I ſhall conclude this diſcourſe with obſerving, and ſhall always firmly maintain, that the miracles of nature are open books, whereby we are all reduced to our eternal origin, nor are we ever elevated above nature and created beings, until we conſtantly love God, and renounce all that is not God.

The end of the wonderful anatomy of the Louſe.

T A B. I.

Explains the changes of the firſt order or claſs, which are laid before the eye, by the aſſiſtance of figures; for which purpoſe the Louſe is produced for an example.

N. B. The numeral letters diſtinctly ſhew, after what manner the tranſmutations ſucceed each other: ſome of the figures are exhibited as they are magnified with the microſcope; and let the reader obſerve in general, that we have likewiſe followed the ſame rule in the examples of the ſecond, third, and fourth orders or claſſes of our changes of inſects.

No. I. Is the Nit or little egg of the Louſe delineated in its natural ſize, wherein the Louſe is contained, being yet cloathed in its firſt coat or skin. The ſame may be ſeen in fig. I. as magnified with the microſcope.

II. The empty ſhell of the egg, or the Nit's coat, caſt off by the Louſe, after it has crept out of it. It is repreſented magnified in fig. II.

III. The Louſe itſelf juſt excluded from its egg, or coat, where it is evident, how this animal has crept out of the membrane wherewith it was covered, in a ſtate of perfection; ſo that it is not obliged to undergo any other change, but afterwards grows to a larger ſize, and muſt often change its skin. Wherefore we have called the Louſe in this form, an oviform Nymph animal; becauſe it comes from its coat perfect in all its members.

IV. We repreſent the ſame Louſe ſomewhat larger, and cloathed as it were in its third or fourth skin, which is likewiſe to be caſt off ſoon after.

V. The Louſe, having attained the full term of its increaſe; in which period we have conſidered it as a Nymph animal; becauſe it is then in the laſt skin that it will caſt, and indeed we find ſome inſects in this firſt order, which are ſtill ſomewhat changed about the time of caſting their laſt skin; which is ſufficiently evident, among other examples, in the longipede or long-legged Spider; the legs of which grow much longer, at the time it is caſting its laſt skin. After this is caſt, the inſects of this firſt order grow no more, nor are they any ways changed; as may be more eaſily underſtood from the figures of the ſubſequent examples of the four orders, under the ſame numbers V and VI.

VI. The Louſe, having attained its perfect maturity and full growth, ſo that is now fit for generation, and is arrived to the ſtate of puberty. Fig. III. repreſents it magnified by the microſcope.

FIG. I.

The Nit or egg of the Louſe delineated with a microſcope.

a. An oviform border or extremity, which ſurrounds the Nit's head; within which are ſeen certain ſmall cups, like uvulæ, of no exact or determinate figure. Theſe little cups are ſomewhat bent, and they again ſwell in the middle, as it were into a whitiſh top. It is obſerved alſo that theſe little cups do not intirely fill the inward parts of the border or circle that ſurrounds the head.

bb. Two tender little ſwellings or pimples, wherein the Louſe's eyes, whilſt its limbs are yet moiſt and ſoft, are ſituated. Theſe eyes grow inſenſibly browner, and become viſible through the ſkin, and at length grow entirely black.

c. A certain white pellucid little part, ſituated in the middle of the Nit, which we have often obſerved to beat regularly like the heart; and this is the little part repreſented by the letter *b.* in figure VI. and called by us the pancreas, as it moves up and down with the ſtomach.

Fig. II.

Th e egg-ſhell, or empty Nit, and the firſt skin caſt by the Louſe.

a. The border or extremity of the head burſt aſunder with its little cups, and driven back by the Louſe creeping out at the upper end.

b. The other part of the caſt and empty ſkin of the Nit, from which the border of the head was ſeparated; ſo that it reſembles an empty tankard, having its aperculum or cover taken off.

Fig. III.

The Louſe lying on its belly, and magnified with the microſcope.

On its head is ſeen a ſhining ſkin, together with ſome little holes and diviſions. On the breaſt or back is an elegant delineation of a ſhield, which is painted in the middle; and the glittering ſkin is alſo obſerved to be here variegated with little holes. The legs, which are fixed to the breaſt, are full of little ſwellings or pimples, like ſhagreen ſkin, but they are loſt by degrees towards the end of the legs. There are many hairs betweeen the claws of the legs. It hath been diſcovered by the microſcope, that at the extremity of the abdomen, the skin likewiſe appears painted and rugged, with little grains like ſhagreen as before mentioned; but I have at length diſcovered with the beſt microſcope, that the skin really conſiſts of irregular ſquares, globules, &c.

Of the Arboreſcent Water Flea *.

After the Louſe I have likewiſe in this firſt order, placed the Arboreſcent Flea, whereof I now intend to treat particularly. This inſect, which I here delineate larger than the life, Tab. XXXI. fig. 1. *a.* is the ſame that in fig. 11. I have repreſented alſo larger, yet in a ſide view. In this, beſides the outward form of the body, which is ſquare as it were, I ſhew an eye in one ſide of the head, fig. 11. *a.* and under it a ſharp beak *c.* On the breaſt are ſeen arms, divided into branches *bb* like the boughs of trees; and in the abdomen there is a tranſparent ſubſtance, with the legs and tail; and in the hinder part of the body, its legs appear placed as it were on the middle of the back.

But if this animal be repreſented in the form wherein it ſhews itſelf to the naked ſight, you would ſay it had only one eye; for the eyes, by reaſon of the ſmallneſs of the head, ſeem to be joined to each other. They are ſituated in the beak of this inſect, and this beak is likewiſe very ſmall and ſharp-pointed. The ſtructure of the eye is ſeen by the microſcope, to be reticulated, or made like a net, ſuch as we ſee in the eyes of other inſects, and the beak is not only ſmall and ſharp, but alſo tranſparent: and it ſeems probable, that this little animal ſucks in its food, by the help of this little part, as is uſual with other aquatic inſects, which feed themſelves with their hollow beak, or tubular aculeus or ſucker.

Of all the parts of this animal, its branching arms, and the motion it makes with them in the water, deſerve out greateſt attention. They ariſe undivided from two, as it were, ſimple trunks, which, like the ſhoulder bones, ſpring from the ſhoulder blades, and are each divided into two branches; each of theſe is again ſubdivided into three different joints. At the firſt and ſecond joint, reckoning from the ſingle trunk, there ariſe on each ſide a little branch, almoſt like a hair; and at the third or extreme joint, three ſuch buds or ſhootings are placed, which alſo ſeem to be again divided into other joints.

But though theſe arms are very remarkable, and worthy of conſideration, the motion produced with them by this inſect deſerve yet greater notice. For this is threefold; firſt, the little creature can, with their aſſiſtance, move in a ſtraight line; whilſt it conſtantly waves its ramified arms, as a bird its wings in the air, ſometimes upward, ſometimes downward, and ſometimes on one ſide, and all the while moves forward in a ſtraight line.

A ſecond motion is like that of the ſparrow, for as theſe, by expanding and again contracting their wings, paſs with an uneven motion through the air, and ſometimes deſcend, and immediately after are carried aloft again; ſo this little animal, by ſtriking the water now and then with its branching arms, obtains a like unequal motion, and ſometimes dives as it were to the bottom, and again riſes up to the ſurface. Theſe ariſe from the alternate ceaſing and repetition of the motion; the animal by this means moving in a different manner. Since, therefore, the motion of this little creature is not at that time very irregular, it happens that it is continually ſeen to jump in the water, its head always tending towards the ſurface, and its tail ſtretched downward.

I cannot find a more proper example of the third kind of motion in this animal, than the whirling or turning about of that kind of pidgeons, which, from this whirling or gyration of the body, are called tumblers. For as theſe tumblers, when whirled about in the air like a ball, ſeem for a time to be deprived of their motion, and fall as it were downward towards the earth; ſo this little creature, inclining its head down into the water, and at the ſame time raiſing the hinder part of its body upwards, moves itſelf as it were in a circle, without any interruption in the motion of its arms, which it uſes upon this occaſion as oars. Hence it happens, that the parts of its body, though in perpetual motion, and naturally always ſunk into the water, are ſometimes ſeen under and ſometimes above it; which is a very pleaſant ſight, and may be compared to the turning of a wheel about the axle-tree of a chariot.

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* This inſect is frequent with us in ſhallow and ſtanding waters, as in the ditches at Tothill-fields.

In regard, therefore, of the motions before explained, by which this little animal ſeems to approach rather to the nature of Fleas than Lice; and on account of its wonderful arms, which are made like the boughs of a tree, I think it may be properly called, as I have named it, the Arboreſcent Flea.

The ſtructure of this inſect's belly likewiſe deſerves as much conſideration as its breaſt and arms: if we view it on the outſide, it will ſeem to be of a rhomboidal form; but in reality, the part which reſembles the belly, is nothing more than a tranſparent skin full of ſcales or ſhells, fig. II, *d*, which is joined together in the back or poſterior part of the body, but in the fore part is divided into two ſegments which open from each other; and thus it forms, as it were, a little open caſement, through which the animal can move his real belly and tail in and out. Therefore this rhomboidal skin which covers the inſect, is only its ſhell, through which its real body is ſeen, as this ſhell is tranſparent. This ſo far agrees with the teſtaceous animals; but it differs from them widely with reſpect to its diſtinctly viſible motions, which it has with the abdomen and tail. I have often obſerved that it ſtretched out its tail through the opening in its skin or ſhell beforementioned, and pulled it in again. This ſubſtance, or the body and tail, are waved and turned round like the letter S; in the middle is ſeen a ſmall tranſparent inteſtine, and in the fore part are ſeen feet which are tranſparent, formed almoſt in the ſame manner as the articulated briſtles in Shrimps, and having the like, as it were, tremulous or jumping motion, wherewith this animal, as well as the Shrimp, can change its place; though this office is performed in general by its arms, to which, however, the legs ſeem to be ſomewhat aſſiſtant. The extremity of the tail is divided into two ſharp and ſtiff briſtly hairs *f*, on which, at a little diſtance, grow two other ſimilar ones. The eggs *h* are placed on the back of the body, which I affirm as certain for this reaſon, becauſe, ſoon after this inſect hath caſt them out, very ſmall whitiſh inſects are ſeen ſwimming in the water, which are of the ſame nature with the full grown ones, nor do they undergo any other change, except that they grow bigger; as I have ſhewn to happen to Lice, in the example of the changes of the firſt order.

In figure III I ſhew all the parts hitherto deſcribed, except only the eggs which are caſt out, with this difference, that a little of the fore part of the body, which was before repreſented laterally, is here delineated; ſo that the motion of the inward body and tail through the rhomboidal ſhell, or skin, may be ſeen the more exactly. The feet alſo may, by this means, be ſeen more plainly, being here ſtretched out beyond one ſide of the skin; which I ſhall make more clear, and explain more particularly hereafter by letters.

The colour of this inſect inclines ſomewhat to red in the full grown; and is like that of beef, which has been ſome time ſteeped in water. The outward ſtructure of the skin that covers it agrees, in ſome meaſure, with the reticulated and checquered ſhell skin of the ſcaly fiſh; though I could hitherto ſee no ſcales in it, having never viewed it through microſcopes, which, in the moſt powerful manner, magnify the bulk of objects: but it is tranſparent like the skin of the Shrimp, or as the ſhells of very ſmall Muſcles and young Cockles. The extreme part of the branching arms is like Hen's feet, but their diviſions are not ſo diſtinct.

I have frequently the inſect I have been hitherto deſcribing, in ciſterns of rain water, when no rain hath fallen for a long time; but when theſe inſects have plenty of rain, they can ſcarcely be ſeen, becauſe they divide themſelves here and there to every quarter. I have found them likewiſe in running water, and in mooriſh or fenny ditches, wherever any of the clear water has ſtagnated on the ſediment at the bottom. They ſometimes remain ſeveral days on the ſurface of the water, and ſometimes are ſeen at the bottom only; but we ſeldom or never ſee them at reſt. They change their skin like Lice, and the caſt skin reſembles the inſect itſelf ſo exactly, that you would ſay, you ſaw it alive. I keep by me ſome skins of this ſort, which are very curious.

I remember when I was in France, in the foreſt of Vincennes, that I ſaw ſo great a number of theſe inſects in a watering-place for horſes, that the water appeared as if changed into blood; which, indeed, terrified me at firſt, but it afterwards gave me an opportunity of inveſtigating the nature of theſe inſects more accurately, and made me cautious not to paſs too raſh a judgment on things that are obvious and familiar to us; for this leads us into innumerable errors and prejudices. It is not impoſſible that thoſe who affirm that bloody rain has fallen, have been deceived in the ſame manner. Is it not poſſible, that ſuch red drops might iſſue from inſects, at the time they come freſh from the Nymphs, which diſtil a bloody fluid? This ſeems to happen, eſpecially when ſuch inſects are more than ordinarily multiplied in any particular year, as we often experience in the Butterflies, Flies, Gnats, and others.

The celebrated Florence Schuyl, who was profeſſor of phyſic in the univerſity of Leyden, long after this incident communicated to me the like obſervation concerning bloody rains. He informed me, that being once intent on his ſtudy, he heard a noiſe, of which, as it increaſed by degrees, he was deſirous to know the cauſe; and that he was ſoon ſatisfied in this particular, for that one of the maid-ſervants ran up to him, and told him, in an interrupted ſobbing tone of voice, that the waters of Leyden were turned into blood. Upon this, he went directly in a ſmall bark to the places he had mentioned, put ſome of the bloody water into a glaſs, and, upon viewing it carefully, obſerved that it was common water, and abounded with little red animals. Thus his ſudden fright was changed into a laſting admiration. Before I treat of other matters, I ſhall diſcloſe a method, to the diligent ſearchers into nature, by which I have diſcovered theſe and ſuch like aquatic inſects in water, which, when found, may be examined more accurately.

To find ſingle inſects in water, I know nothing more proper than the glaſs veſſel commonly called an urinal; for if its empty belly be ſomewhat narrow, the ſmalleſt animal ſwimming in it muſt be ſeen by us, ſince the water itſelf contained in it ſupplies the place of a microſcope. As the glaſs, therefore, is wider or narrower, ſo we ſee the little animal repreſented leſs or greater. But it muſt be obſerved, that this augmentation is not viſible, except only when the animal ſwims on the oppoſite ſide of the glaſs. When the inſects are once obtained, they may be removed into ſmaller glaſs bottles, wherein the parts may be ſeen much more diſtinctly: nay, the microſcope, conſiſting of only one convex glaſs, may upon this occaſion be uſed to advantage. Beſides theſe, we have likewiſe other helps to magnify theſe little creatures: we have cauſed very ſmall round bowls to be made of glaſs with diviſions, in which we have, by the help of a microſcope, viewed the inſect, having only a little water, to the utmoſt advantage; and gained a very diſtinct knowledge of all its parts. It may likewiſe be very conveniently examined by the microſcope, if it be placed in a ſmall drop of water, dropped upon white paper; provided one takes care to avoid the brightneſs produced by the water. If the inſect ſhould happen not to be diſtinctly ſeen upon a white ground, we may change the white into yellow, green, blue, or any other colour: we have, for this purpoſe, put our little glaſs bowls before mentioned, into a cake or compoſition of ſtarch and blue, into ſoot, vermillion, and other paints; and by this means our endeavours have been crowned with a fortunate event. Since, therefore, the method we have been hitherto explaining, has been very uſeful to ourſelves in diſcovering a great many water inſects, and viewing their parts with the help of a microſcope, we no longer deſire to conceal it, but communicate it for the ſervice of the public. To this we ſhall add, that among all the kinds of microſcopes which have been invented, none is better than that which has only one lens. But ſince we owe the benefit of this inſtrument or contrivance to that very great and incomparable mathematician, Mr. John Hudden, ſenator of the city of Amſterdam, we eſteem it our duty to do this renowned gentleman honour; and to give him public thanks for the favour he has done us in this reſpect.

A particular treatiſe on the Scorpion, which likewiſe belongs to the firſt claſs or order of natural changes.

NEXT in order under this head, come the Scorpions, which are viviparous, according to the obſervation of Dr. Francis Redi; his words are theſe: "The thoughts "of the great Ariſtotle were juſt, who is of "opinion that Scorpions are generated by the "conjunction of the male and female; the "Scorpion not laying eggs, like other inſects, "but bringing forth little Scorpions alive and "perfect in their ſpecies: and of this opinion "are alſo Pliny, Lib. II. Cap. xxv. and Ælian, "Lib. VI. Cap. xx; and the ſame thing has "been accurately obſerved by Thomas Furenius, "and by the very learned John Rhodius, "in their medical obſervations.

"As, therefore, I had nothing to follow or "avoid, I began at once my experiments; "and having brought a large quantity of Scorpions "from the mountains of Piſtoiæ, in "Tuſcany, I ſelected ſome of the females, "which, by their ſize and roughneſs, are "eaſily diſtinguiſhed from the males, and on "the 20th of July put them in ſeparate glaſs "veſſels, and kept them without food; ſome "of them died before they brought forth their "young. But one of thoſe on the 5th of "Auguſt brought forth, not eleven, as Pliny "and Ariſtotle have imagined, but thirty-eight "Scorpions, well ſhaped and of a milk-white "colour, which every day changed more and "more into a dark ruſty hue. Another female "in a different veſſel brought forth "twenty-ſeven of the ſame colour, on the 6th "of the ſame month; and the latter, as well "as the former, ſeemed fixed, as it were, to "the back and belly of the female. On the "19th all theſe young ones were living, but "afterwards ſome of them died daily, ſo "that I loſt all ſoon after, except two which "ſurvived until the 24th of Auguſt, and "then they died alſo.

"In the mean time, I had a mind to ſee "how theſe inſects were placed in the parent's "womb before their birth. Having, "therefore, opened ſome of them, I found "different numbers, yet never leſs than "twenty-ſix, nor more than forty; all which "hung on an oblong thread, and were covered "with a very fine and delicate membrane, "in which one Scorpion was very clearly "diſtinguiſhed from another, by a certain partition "reſembling a fine film." Thus far Dr. Redi, in Exp. Circa Gener. Inſect. But the deſcription given by him does not at all ſatisfy me, ſince his deſcription of the uterus and its oviducts is not ſufficiently exact; nor does he take any notice of the place where the oviducts are connected with the uterus, and form one common excretory duct. I ſhould likewiſe be glad that the extremities of the oviducts had been examined by him, and that he had deſcribed the rudiments of the eggs contained in them. He ſhould have told us, what that oblong thread is of which he makes mention, and which was doubtleſs one of the oviducts. The membrane, likewiſe, which ſeparated the Scorpions from one another in the oviduct, could be no other than the membrane which covers the fœtus of this inſect, and ought indeed to be called the proper egg of the Scorpions. It is probable that he found this egg in the extremities of two oviducts; though his words import, that there was only one oviduct, which he calls an oblong thread; which ſeems to me ſcarce probable, ſince we are taught the contrary from the analogy there is between the uterus and oviducts in all inſects. And when he makes mention of a partition, which, like a very fine film, ſeparated the young Scorpions, he ſeems in that place to divide an oviduct: but the author, ingenious as he is, ſpeaks here ſo perplexedly and obſcurely, that it ſeems as if he intended to propoſe an enigma for ſome future Ædipus.

I am perfectly ſatisfied that Scorpions, which I have never known to be refered to any order, ought to be inſerted in the firſt of my plan, with this difference only, that they are brought forth alive; whereas the Louſe only lays eggs or nits, from which its young afterwards proceed. The Scorpion is, therefore, like the viviparous Snail, which excludes its eggs in its own body, and afterwards brings forth its young alive, but at different times and intervals; whereas the Scorpion has thirty-eight young ones together at one birth, which afterwards, by degrees, increaſe and grow bigger.

As the true figure of the Scorpion has not yet been given by any perſon, that I know of, I ſhall here repreſent their natural ſhape. And that I may the more accurately execute this, I ſhall divide the Scorpion into the head, breaſt, and belly. The Scorpion's head ſeems jointed, as it were, to the breaſt, as I have found in all the dried Scorpions that I have ſeen hitherto. In the middle of the breaſt, or in the head connected to it, are two eyes; and a little further towards the fore parts, there is likewiſe another pair of eyes, placed as it were in the forepart of the head. Under theſe are obſerved two ſhort arms, forceps or pinchers, Tab. III. fig. 1. *a*, which the Scorpion, doubtleſs, makes the ſame uſe of as others animals do of their teeth, and with which it breaks its food, and thruſts it into its mouth. Theſe four ſhort forceps, and the four eyes above them, have never, to the beſt of my knowledge, been obſerved or deſcribed by any perſon, but hitherto entirely neglected. The Scorpion can at pleaſure put back theſe forceps or teeth into its mouth, ſo that none of them may be ſeen.

Under the breaſt are eight articulated legs *bb*, each divided into ſix joints, the two hindmoſt of which are each provided with two crooked claws, and the legs have here and there ſome hairs. At the foremoſt extremity of the head are two flagella or whips, or crooked arms like pincers *cc*, compoſed of four joints, the outmoſt whereof is fortified, as it were, with a thumb, by the contraction of which the forceps is formed. This joint is thick and ſtrong, and contains ſtout muſcles, as we likewiſe obſerve in the claws of Lobſters. The belly is divided into ſeven little rings *d*, from the loweſt of which ariſes a tail compoſed of ſix joints, which are briſtly and formed like little globes *e*; the laſt of theſe joints is armed with an aculeus *f*, or ſting.

Dr. Redi ſays, he ſaw that the Scorpion diſcharged a very ſmall drop of water through the ſting in its tail; which I ſhould eaſily believe, ſince the poiſon infuſed by Bees through their ſting into a wound, likewiſe conſiſts of a very clear liquor. And this makes me ſuſpect that the external ſting of the Scorpion, in like manner as in Bees, is no more than the ſheath, wherein the true aculeus or ſting is concealed. I once undertook to examine this matter in a dried Scorpion, but ſince the loweſt ring of the tail, from which the ſting hangs, became hard as a horn by drying; I could not accompliſh my deſign according to my wiſhes. I obſerved therein, however, two ſmall tubes, which ſeemed to end in a ſacculus or little bag, that carried, I ſuppoſe, the poiſon, and had on the fore part two aculei or ſtings; but all theſe things were ſo confuſed, that I would not preſume to affirm any thing certain concerning them. If I had had the Scorpion alive at that time, and ready at my hand, it would have been very eaſy to have clearly diſcovered this matter.

In another kind of Scorpion, fig. 11. I ſaw that the two foremoſt crooked arms *aa* differed very much from thoſe which I have before deſcribed; for the forceps were, in compariſon to the former, very ſmall, and ended in a ſharp point. On the fore part of the head were, like theſe, two forceps or teeth beforementioned; and above theſe on either ſide were three eyes, ſo that there were ſix in all. In all other particulars it was like the former Scorpion; unleſs that in the reſt of its limbs there was here and there ſome very ſlight difference, as is ſeen in the figure. This little Scorpion was very delicate, and it may be eaſily known, from the ſmallneſs of the forceps, that this kind have leſs ſtrength than thoſe of the former; but then the longer they are, the more conveniently they can take hold of their food.

As the larger the animals are, we can attain to the more accurate knowledge of them; I ſhall now repreſent again, in a very large Scorpion, all the parts which I have deſcribed in the two former; particularly thoſe two briſtly teeth, or foremoſt forceps, fig. III. *a*, are in this ſeen very clearly; as alſo its two foremoſt eyes *b*, of which there are ſix on each ſide of the head, ſome gradually leſs than others. In the middle of the head, where it is connected with the breaſt, are two eyes, which may be diſtinguiſhed eaſieſt of all, and which have therefore been alſo obſerved by all authors; who, notwithſtanding, ſeem to take no notice of the twelve other eyes. The head, breaſt, belly, tail and ſting, together with the legs, forceps, hair and claws, are likewiſe much more conſpicuous in this than in the two former. The ſix joints of the legs are exactly in this the ſame as they are in the ſmaller Scorpions. The crooked arms of this alſo conſiſt of four joints, and carry forceps of an horrible bigneſs; but there is a peculiar difference in the tail, ſince it is divided into ſix joints in ſmall Scorpions, and in this had only three: I doubt, however, whether this be ſo by nature, ſince I think I could perceive that the tail had been broken, and glued on again before it came to me; but all the articulations were not joined together. The colour of this Scorpion is very black, like pitch.

I have another Scorpion almoſt the ſame ſize with the laſt, having a tail compoſed of five joints, whereof I have the ſame ſuſpicion that I had of the former, that is, that it is not natural to it; for I am thoroughly perſuaded, that in all kinds of Serpents the tail conſiſts of ſix joints. The latter was brought me from America, but the former very large one, the figure whereof I have given before, from the Eaſt-Indies. The figure of the American Scorpion is like that from the Eaſt-Indies. Doctor Padbrugge, governor of the Molucca iſlands, has this year ſent me a drawing of a peculiar Scorpion, which was of a light red, but is now grown of a blue or ſky-colour; its tail is compoſed of ſix joints, and in other particulars it differs not from the very large one which I have repreſented, only that it is not half ſo large.

In Holland there is found a certain ſpecies of Scorpions, which are very ſmall, and no bigger than a Bug; they likewiſe reſemble it in the hinder part of the body, which is divided into eleven ſmall rings, and wants a tail. They have ſix legs, each of which conſiſts of four joints. The breaſt, which is connected with the legs, is diſtinct from the head; the forepart of which has a pointed beak covered with hair. They have likewiſe many eyes, which are diſtributed over the ſides of the head: the crooked arms are placed before the eyes, and ſpring from the head like the antennæ or horns in Butterflies, being compoſed of four joints, including the forceps, the ſtructure whereof is the ſame with that of the Scorpion's before repreſented in fig. II. All theſe parts have on them ſmall, briſtly hairs, and are of the ſame colour with the common Scorpions of Germany and Italy. The arms before-mentioned are very long and large, in compariſon of the ſize of this animal; nor can there be a more agreeable ſight than the remarkable motions it makes with their aſſiſtance, when it changes place, and moves itſelf like a land Crab. This inſect is often found in benches, cheſts and coffers, that have not been cleaned for a long time, where, in my opinion, it maintains itſelf on thoſe little animals which there multiply in the duſt, and of which there are many kinds; ſeizing them, I ſuppoſe, with its forceps, and ſwallowing them for food. I have likewiſe found this inſect in ſcarlet cloth, which had been kept long in a cheſt. I have nothing farther to ſay of this animal; I have deſcribed it according to the parts that I have found in it, when fixed on a needle and dried.

The natural hiſtory of the covered Snail, illuſtrated by accurate drawings.

The INTRODUCTION.

THOUGH the Snail was reckoned by the Jews among unclean animals, which they were forbid to uſe as food, they did not ſcruple the application of it to other purpoſes. The royal pſalmiſt borrows a moral ſimile from it, and prays, that the wicked may "conſume away like a Snail;" and, however impure and ſlimy, it muſt notwithſtanding claim the conſideration of thoſe, who are deſirous of being acquinted with the wonderful works of the creation.

There are many chriſtian nations who place Snails amongſt the dainties of the ſecond courſe, but they are only thoſe of a particular kind. In Holland no Snail is uſed for this purpoſe, but the valved kind found in the ſea or other waters, the muſcles being of a pretty tenacious ſubſtance. The way of eating them, is boiled and well ſeaſoned with ſalt; and no part of them taſtes ſtrong except the liver.

Other nations, as the Italians, Germans and French, eat the garden Snail, eſpecially at the ſeaſon, that, after a faſt of ſeveral months, it has cleanſed itſelf of all impurities; for during this period, there grows upon the mouth of the ſhell a covering, compoſed of a ſubſtance not unlike plaſter, which hinders the earth or any kind of dirt from getting into it. In this manner this kind of Snail paſſes more than ſeven months, from autumn to ſpring, without any motion or food.

The ſhells, blood, and opercula of the Snail kind have likewiſe their uſes in medicine. Amongſt the opercula of Snails, that called Blatta chiefly deſerves our attention; it belongs to the Murex or purple Snail, and as it comes to us from Byzantium, a town in Africa, where the art of dying purple formerly flouriſhed, it has obtained the name of the byzantine Blatta. However, this word Blatta is now made uſe of, to ſignify the opercula of all kinds of ſhell fiſh without diſtinction, though there are ſo many and ſo great differences in this ſingle part, that an entire treatiſe might be wrote on it alone; and certainly ſuch a treatiſe might be very uſeful, as well as entertaining.

My intention, at preſent, is to treat of the Snail, known by the name of the vine or covered Snail, and deſcribe its manner of living and propagating its ſpecies, which I have made myſelf acquainted with by a very exact diſſection: by means of this, I ſhall, among other things, prove, that in this creature both the brain and ſpinal marrow have their proper muſcles; and ſhall likewiſe ſhew in what manner this, in appearance, ſo contemptible a creature is provided, by the greateſt of all wonders, with eyes, that may not only be diſtinctly known for ſuch, but even felt; and how it is at once both male and female in the ſame body; as alſo how it proceeds by generation, from an egg, like other animals. Hence will appear the folly of that common opinion, which makes them proceed from ſlime or mud, a fancy which could only find place in the empty heads of thoſe, who, inſtead of ſtudying God's wiſdom, power, and goodneſs in his works, ſpend their lives in reading books which miſrepreſent them, or at beſt, only repreſent them at ſecond hand, ſtealing from one another.

Hence alſo it will appear, that this animal is to be ranked in the firſt ſpecies of my four natural orders of mutations, in which inſects proceed immediately from an egg, without paſſing through any intermediate ſtate, as I ſufficiently have deſcribed in the general hiſtory of inſects.

I ſhall here deſcribe that kind of Snail, to which the inhabitants of Brabant and Flanders have given the Spaniſh name of Caracol. It would be an endleſs task to treat particularly of every ſpecies of Snail, Cockle, Periwinkle, and other creatures of this kind, that are found with or without ſhells, though all belong to the ſubject we have in hand; ſince for this purpoſe, it would be requiſite to call all nature together, and ſearch the ſeas and rivers, and every part of the earth.

Nevertheleſs, I ſhall take notice, in the proper place, of what I have occaſionally ſeen and obſerved in other kinds of Snails; ſuch as the houſe Snail, which has a little ſtone for its ſternum; likewiſe the common Snail, which we meet with in path-ways, without any ſhell like the firſt. I ſhall alſo ſay ſomething of the garden Snail, the freſh-water Snail, the Crab, or ſalt-water Snail, the mother of pearl, and ſome other kinds of Snails, which I have had opportunities of ſeeing and examining. Some of theſe live upon trees, and there are others, but very ſcarce, which have the ſpiral line deſcribed by thin ſhells turned the contrary way.

CHAP. I.

Of the ſhell and ſoft part of the Snail in general, and particularly of the four horns which ſpring from the upper part of its head, and of the eyes that appear in them, with a deſcription of the conſtruction and motion of thoſe parts.

BEFORE I begin to ſpeak of the body, or ſoft part of this creature, I ſhall ſay ſomething of the ſhell or hard part: this is prepoſterouſly called its houſe, if we take that word in its proper and common ſignification, ſeeing it is the very ſkin of the Snail, without which it would be as impoſſible for it to live, as for a Lobſter, or a man who had been flayed, or a tortoiſe drawn out of its covering. This cruſt therefore ought to be conſidered as the bone of the Snail, in which all its muſcles are inſerted, as the muſcles of quadrupedes are fixed in theirs. This is very obſervable in ſea Muſcles, as I ſhall in its proper place accurately demonſtrate.

To paſs now to the ſoft part of the Snail's body; it is to be obſerved, that what appears of this part, when it moves forward with its ſhell, is about three inches and a half long, and almoſt two inches broad. In the fore part of its head appear four horns, two greater, Tab. IV. fig. 1. *aa*, and two leſſer *bb*, without any ſpots at their extremities. Under theſe horns we may perceive its external lips, and its mouth *c*, and between the firſt and the ſecond horn is the perforation *d*, from which iſſue the organs of generation, when they ſwell up for that purpoſe; at other times this hole is ſo nicely cloſed as not to be diſcernible. Behind, towards the edge of the ſhell, is a thick border or lip, which on every ſide, both within and without, adheres firmly to the external edge, and internal ſurface of the ſhell; but this part is like the ſkin, which in naked Snails hangs under the fore part of the body; and under which, as under a veil, they hide their head and horns when they are touched. In this lip or border there are on the right ſide two openings, one of which *f* ſerves for the creature to diſcharge its excrements, and the other *g* to breathe. In the body there evidently appear thoſe flat and broad fringes *hhh*, by the help of which, chiefly, the creature moves: they conſiſt of very ſtrong muſcles, for which reaſon I call them the Snail's feet, as reſembling in ſome meaſure the feet of Bats and Ducks; whoſe claws are connected to each other by a membrane. This ſort is covered underneath with a thin skin, and the upper part is bent, with a number of glandulous ſpots or warts of different forms, amongſt which there run a great many veſſels: but I ſhall hereafter ſpeak more at large of theſe particulars.

Fig. II. If after having taken the foregoing ſurvey, we entirely ſtrip off its ſhell, or rather ſtony bone *c*, from the tender part of its body, we ſhall find the fleſhy part which heretofore lay hid, is exactly of the ſame ſpiral form and ſhape, fig. I. *k*, with the ſhell that covered it, but then it is perfectly tender, without the leaſt ſenſible hardneſs.

Here all the inteſtines, in a manner, appear through the extremely thin and tranſparent membranes of the body, which are all over ſpread thick with veſſels: for the hard ſurface being once removed, the leaſt puncture made in the skin that remains, is followed by the effuſion of the Snail's blood, like a mucous humour, of a pale purple colour. This can only happen from the body's being all over pervaded by a great number of veins and arteries, ſo that on dexterouſly clipping the ſmalleſt portion of its foot or border, you may perceive little ſtreams of blood iſſuing from the wound.

To remove the ſhell or bone of the Snail, it is beſt to uſe a pair of flat pincers, by means of which the ſhell or bone may be gradually broken and torn away, till we come to the part where the muſcles of the body are inſerted into it. Tab. VI. fig. II. *a*. The tendons of theſe muſcles muſt afterwards be ſeparated by a flat ſpatula; we muſt then proceed as we begun, by gradually breaking and tearing away the remains of the ſhell, till there are but one or two twiſts left; out of which the little tail in which the body terminates may be then drawn without any difficulty.

All the four horns, Tab. IV. fig. I. *aa*, *bb*, agree with the upper part of the skin of the body, in being adorned with little glandulous unequal grains, fig. V. *eee*, like ſo many warts; but thoſe on the horns appear the ſmalleſt and moſt exquiſitely divided. The horns themſelves, when viewed through a microſcope, look as if they conſiſted of a greeniſh tranſparent ſubſtance, like veal gelly, through which appear ſome whitiſh ſpots; theſe I take to be the glands made uſe of by the creature for the ſecretion of its ſlimy or mucous humour. This ſlimy matter ſerves to moiſten conſtantly not only the whole body, but the horns; and in my opinion, the conſtant moiſtening of the latter is extremely neceſſary, conſidering how often and how ſwiftly the Snail is obliged to ſtretch them out and pull them back again; an exerciſe which, without ſuch a contrivance to keep them ſlippery, could never be performed.

Though all four horns are very remarkable, the two uppermoſt and longeſt deſerve our particular conſideration, both on account of the power of motion given them by the ſupreme architect, which is very ſingular, and exceeds all human art; but more eſpecially becauſe they have evident eyes, appearing like two blackiſh points, in their extreme ends: they at times ſtretch theſe eyes in a manner not to be deſcribed, yet by a regular motion, out of the body; and ſometimes they hide them by a very ſwift contraction in the cavity of the abdomen.

I know, indeed, that many who have laboured to inveſtigate the nature of theſe little creatures from ſpeculation only, have given the name of eyes to theſe blackiſh ſpots viſible in the tips of the horns; but their own fancy has afterwards made thoſe very perſons change their opinion, when they ſaw that the Snail ſtruck thoſe horns almoſt againſt every object, and that they ſhewed no ſigns of quickneſs of ſight. But the knowledge of nature cannot be acquired by reaſoning only, for unleſs we make experience go hand in hand with reaſoning, we ſhall err all our lives*. I ſhall therefore lay aſide all conjecture, and deſcribe theſe eyes and their membranes, humours, muſcles and nerves, as I have ſeen them, that the hidden, and for ever to be celebrated miracles of God may be made manifeſt to all lovers of his works, who have not opportunity to ſearch themſelves into theſe matters.

Thoſe who thirſt moſt after true knowledge, are with reaſon afraid, leſt the poiſon of falſities ſhould be offered to them, inſtead of the food they ſeek of true knowledge.

To methodize and ſet all theſe things in a clearer light, I have ſubjoined the figures of all theſe parts immediately after their deſcription. The firſt thing that deſerves notice in the examination of the upper horns, is their extremity, in which three particular little parts are obſervable. The firſt of theſe little parts is placed in the middle, and is a very black ſpot, Tab. IV. fig. I. *aa*. This is the real eye of the Snail, fig. V. *a*. The ſecond is the optic nerve of this eye *b*, which, by a certain production like a little globe, ſwells and appears through the skin. The third, conſtitutes the extreme end of the muſcle of the eye *c*, whereby the external skin, which is equally extended thereon, is firſt bent in or drawn back, when the Snail endeavours to draw its eyes into its body. This motion always begins about that part or diviſion of the eye *d*, which lies in the middle between the muſcle and its nerve. But as the apex or end of this muſcle is ſomewhat more prominent than the eye or its muſcle, it therefore firſt receives all injuries, whenever the creature happens to ſtrike its little horn againſt any thing. Thus the eye is defended and kept ſafe. Moreover, theſe extreme ends of the horns are ſtretched ſmooth, and have a bright ſurface, ſomewhat red, and full of prominences or little warts; but the glands *eee* appear to be ſituated a little lower, between the globular production of the horn, and they are likewiſe divided on the inſide by very ſmall whitiſh points. The furrows or ridges viſible at the bottom between theſe glands, are the veſſels which carry the glutinous humour to all theſe parts, and again bring it back from them. And that theſe muſcles and nerves may lie convenient, the whole horn is hollow *f* on the inſide; ſo that if it be diſſected tranſverſely, the extremities of theſe parts preſent themſelves on the inſide.

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* Perrault, after many obſervations, expreſſed his doubts, whether Snails had really any eyes or not; and Dr. Brown has placed his opinion of their having any among vulgar errors: but this author's obſervations are confirmed by many ſubſequent examinations; and very lately, Dr. Peterfield has ſhewn, they are to be ſeen very diſtinctly. His account is publiſhed in the Edinburgh eſſays.

To have a more clear idea of this matter, it is neceſſary to open the Snail, for which purpoſe you muſt have a ſmall and ſharp-pointed pair of ſciſſors; one of the points of theſe ſhould have a little ball made of ſealing wax fixed on it, to prevent the inward parts from being wounded. Then, after opening the middle of the back, the body muſt be cut to the verge of the Snail, Tab. IV. fig. I. *e*; after this direct the ſciſſors forward, and diſſect the ſkin as far as the fore part of the head, between the two upper horns. The diſſection being thus made, the firſt thing to be met with, immediately under the ſkin, is a certain muſcular delicate membrane, which is very thin and fine; it covers all the inward parts, and is provided, here and there, with muſcular fibres, which run acroſs from one ſide of the body to the other, and are inſerted into the ſides of the ſhell; you may alſo then ſee the ſtomach, organs of generation, and the like. Afterwards the brain, which lies on the upper part of the ſtomach and over the gullet, preſents itſelf; and immediately afterwards, the horns themſelves drawn back, with their muſcles in the abdomen.

Having thus briefly touched upon theſe matters, I ſhall proceed to explain and deſcribe by figures, how theſe four horns, Tab. IV. fig. VI. 1, 2, 3, 4, are circumſtanced, when they are drawn into the body, and their inward ſides are turned out; for which purpoſe, each of the horns has its proper muſcle. The two upper and largeſt horns have their particular muſcles *aa*, each of which is connected by its proper tendon to the two muſcles which move the middle of the body, and theſe are afterwards with them inſerted by their tendons into the ſpiral part or folding of the ſhell, Tab. VI. fig. II. *hh*, *nn*, *a*.

The two lower horns, not being of ſuch importance as the upper ones, are provided with two ſmaller muſcles *bb*, which ariſe from the larger *cc*, and draw in the lips of the ſnail. This is likewiſe repreſented in Tab. VI. fig. II. *ll*, *mm*.

The manner in which the horns are twined and ſtretched out of the body, is a much more difficult thing to be deſcribed; though I think, indeed, that the inward coat, or muſcular part of the horn, performs that office, with the aſſiſtance of ſome other ſmaller and adjacent muſcles, as well as ſome ſtronger ones, whereby the fore part of the head, and the ſkin of the ſnail is moved towards the outſide. The true action, which I think the inward annular muſcles have, ſeems to conſiſt in this, that ſome of them are ſucceſſively contracted and ſtiffened after others, by which means the horn is continually rolling out, and one ſmall portion of it is puſhed after the other; to this action, the periſtaltick motion of the inteſtines, as far as the latter is performed by the contraction of the annular muſcles, bears ſome, though perhaps a diſtant, reſemblance.

But the optic nerves deſerve more conſideration, both on account of their texture and their motion. Before I deſcribe theſe, I ſhall take occaſion to ſay ſomething of the brain, from which they ariſe. The brain *d* conſiſts of two globular little parts, and, by this property, is divided into two portions, as it is in man. The firſt is placed in the head; but becauſe this, as well as all the other parts of the ſnail, is, in a wonderful manner, moved ſometimes backward and ſometimes forward, no fixed or certain place can be aſſigned to it. I therefore ſhew both the brain and optic nerves in the ſituation wherein I have delineated them. The hinder part of the brain, is drawn in Tab. IV. fig. VI. *e*, to the ſkin of the ſnail's head, and is ſituated a little above its ſhining tooth *f*; for the brain, together with all the parts of the gullet and mouth *g*, and alſo the ſtomach and ſalival veſſels *ii* are driven to this depth into the body, by the ſtrength of a muſcle appointed for that purpoſe; but when all the parts are again rolled or turned out, we may then ſay, the brain is placed at the fore part of the head. Hence it is evident, that the motion of the brain in this creature ought to be obſerved as a thing worthy of the higheſt admiration; wherein both the wiſdom and infinite power of the almighty are manifeſt: ſince he has been pleaſed to render this part, which in man and other animals he made immoveable, by encloſing it in a hard bone, capable of motion in the ſnail, by the power of its muſcles.

The optic nerves of the firſt pair of horns having ſpiral originations *kk*, ariſe on both ſides from the brain, which has been ſo contrived by the omnipotent wiſdom of God, that they might conveniently obey, and evolve or turn themſelves out, when the horn is, in ſo ſtupendous a manner, protruded forth out of the body; and to prevent the leaſt diſorder from this egreſs and regreſs, the omniſcient creator of the univerſe hath involved and fortified theſe nerves with ductile membranes *ll* and ligaments, with ſo much art, that no ſuch diſorder is ever to be feared. Nay, leſt this nerve ſhould be in any danger, when it is turned up and down inwardly in the cavity of the moveable horn, the wiſeſt of all architects has conſtructed that part of the muſcle which is fixed to the extremity of the horn in ſuch a manner, that at the ſame time it performs the office of a ſheath or caſe, wherein *m* the nerve lies in perfect ſafety, ſo that it appears to be faintly viſible through it; it may, however, be diſengaged from this covering, and then its ſpiral windings appear ſo admirably conſtructed *n*, that any perſon who contemplates this prodigy of nature, muſt be aſtoniſhed and ſtruck with amazement.

That muſcular, and at the ſame time membranous, little part which covers the nerves, is ſo tender in this place, that it may be very eaſily ſeparated, and divided into parts, with the point of a needle, or with an ivory bodkin; after which the muſcle reſembles as it were a grey delicate membrane, Tab. IV. fig. VI. *o*. The nerve itſelf ſwells by degrees into a globular form *p*, at the end of which is placed an eye *q*; of which I ſhall preſently ſpeak particularly.

The little nerves *r* of the two lower horns, do not ariſe directly from the brain, but have ſome parts intervening; but as to the twiſted nerves *s*, which are conveyed towards the fore part of the skin, to the root or baſis of the horns, they have there the ſame texture with that of the nerves that belong to the upper horns, though they have no eyes in the ends of them. The ſame order, in every reſpect, the ſame wiſdom and providence, are manifeſted in the conſtruction of theſe lower, as we have before mentioned in relation to the upper, pair of horns.

The two ſmaller of theſe little nerves ſpring immediately from the baſis of the brain, and are diſpatched in the ſame manner as to the larger horns *t*. In fine, all the muſcular parts of the palate, mouth, and jaws, which I ſhall hereafter deſcribe particularly, are furniſhed with two ſmall nerves *v*, which adminiſter to their motion; theſe I have repreſented in Tab. VI. fig. I. at the letters *hh*, where may be ſeen the method in which they are bent, when the brain is moved forward.

Fig. VII. *a*. The eye itſelf is very conſpicuous, and in ſome degree of the form of a round onion; but is a little flatt or ſmooth on the verge, and ſwells ſomewhat into a point where the ſight is exerted. But I could not obſerve that the eye has more than one coat, which covers it on the inſide, and which I call the uvea; if this uvea be in the leaſt, ever ſo lightly, touched, it makes the place it lies on very black, like ink: this I ſhall ſhew more clearly hereafter, for I now only deſcribe the eye, as it appeared to me through a microſcope. I here likewiſe ſhew the grey muſcular membrane *bbb*, which covers the eye; and I alſo exhibit the manner, wherein the circumference of the eye is connected with it: the optic nerve *c* is here repreſented likewiſe larger than natural, and its texture and form are ſhewn; and after what manner the eyes are placed thereon. Here is likewiſe ſhewn how the inverted horn *d* is connected to all theſe parts, and the cavity *e* it paſſes through; as alſo after what manner, and in what place, it is protuberant *f*; on account of the muſcle which draws it back into the body of the creature; and which is there fixed in the end of it.

I have obſerved five diſtinct and viſible parts in the eye of the Snail, as clear as the ſun at noon; firſt, the external coat, which I call the uvea; afterwards on the inſide, the aqueous, the chryſtalline, and the vitreous, humours, with the arachnoide tunic. But who can credit this? for it ſeems indeed improbable that on a point not bigger than the nib of a writing pen, ſuch exquiſite art, and ſo many miracles, ſhould be diſplayed. But what is there that equals the power of God, who is the contriver and creator of all theſe things? nor can there be any room for chance here, unleſs in the opinion of thoſe, who deſtroy and reject the ſteps of natural knowledge, leſt they ſhould aſcend in her paths, and be led to the wiſeſt of architects; and, by contemplating even the moſt minute of his works, be incited to proſtrate themſelves with a ſacred reverence, and moſt profound humility before him, bidding adieu to their own opinions and former life, which, without the love of God, has been hitherto addicted only to the world.

If the uvea be viewed with a microſcope, it has the appearance of a turnip roaſted in the fire, until it is very black, and burſt in ſome places; and has ſome viſible ſmall fibres, which connect it with the adjacent parts. But when this eye and its coat are put, with a very fine pencil, into the fourth part of a drop of water, for more water would overflow it, and, after ſtirring them a little, they are cautiouſly and ſlowly touched; the water at length becomes black likewiſe, and ſhews the remains of the particles ſwimming in it: the ſame thing will happen alſo if an experiment be made on the uvea of the human eye. But when all the moiſture is wiped off clean, and a little wound is made in the eye with two fine and very ſharp needles, Tab. IV. fig. VIII. *a*, the aqueous *b* humour will be obſerved to burſt out from thence. If this eye be afterwards preſs'd more roughly, you will ſee a more clammy humour iſſuing from thence *c*; which is properly the vitreous humour. And laſtly, after that, the chryſtalline humour, which is of a harder conſiſtence, and of a plane round figure *d*; it is limpid, tranſparent and ſhining; but it does not run out, until you break the arachnoide coat, which covers it, and which is the fifth part of this eye. From theſe obſervations we learn clearly, how "the "inviſible things of God, from the creation of "the world, are clearly ſeen, being underſtood "from the things that are made, even his eternal power and godhead, ſo that they are "without excuſe, becauſe that when they "knew God, they glorified him not as God." "Rom. i. 20, 21.

The uſe of the eye in the Snail, and the manner wherein it exerciſes its viſual faculty, is a matter of great difficulty to inveſtigate. The grey coat, Tab. IV. fig. VII. *bbb*, which is the expanſion of the muſcle of the eye, and may be very much dilated and contracted, ſeems to me to move various ways; nay, that it ſerves as a cover like our eye-lids: but the bigneſs or ſmallneſs of the pupil or foramen, or aperture of the uvea, and in what manner it is contracted or dilated, as light and objects vary, I have not hitherto been able to obſerve, nay, I never yet ſaw the pupil of the eye in a Snail; nor ſhould any wonder at this, if in the human eye, though ſo big, the foramen or aperture of the pupil is no larger than a Pidgeon's quill; what a ſmall and fine aperture then muſt the pupil have in this little point, and how few rays can paſs into it? however, I don't doubt but the pupil is contractable and dilatable; for I have obſerved the ciliary duct there, by which, when the pupil is dilated, the eyes of the Snail can receive the humors, and collect external viſible objects, which, after paſſing the humors, are afterwards received in the retina, placed underneath at the bottom of the uvea, by the optic nerve; which is the cauſe of viſion. Hence it may, perhaps, be juſtly inferred, that the ſight of the Snail muſt of neceſſity be very dim; for we ourſelves do not ſee clearly in the day-time, if we go into a houſe out of the open air; the pupil of our eye is by that contracted in ſuch a manner, that fewer rays of light are collected in our eye. Nay, perhaps the Snail does not receive the rays of light and objects but at a diſtance, and only ſees them through a cloud as it were, and cannot diſtinctly know them near at hand; as the man born blind is ſaid in the goſpel to have ſeen men like walking trees: I could not at leaſt hitherto obſerve, that the Snail ſees well the things which are near it, notwithſtanding all the attempts I made for this purpoſe. In the eye of the Mole I have likewiſe ſeen, even without a microſcope, the three humors beforementioned, but they are there larger, and eaſier to be diſtinguiſhed, though it is probable even this creature cannot ſee diſtinctly under the earth.

I ſhall conclude this chapter with admiring the ſtrange and remarkable things which I have ſhewn in it, from the cleareſt experiments, and which ſeem to me the more admirable, the more diligently I meditate upon them: God truly every where ſhews that he is worthy of the moſt humble adoration in all his works, which we may and ought diligently to ſearch into, but can never fully comprehend.

CHAP. II.

Of the lips, mouth, teeth, tongue, palate, œſophagus or gullet, and certain muſcles of the Snail.

BETWEEN the two lower horns of this creature are ſeen its lips on the outſide, Tab. IV. fig. I. *c*, and whilſt the Snail draws them aſunder, the intermediate skin is obſerved to be ſet like the edge of a ſaw, as it were with prominent little teeth. This can never be ſeen better than while the Snail is eating, or when the mouth, palate, and jaws, together with the outward skin, are taken off and diſſected. In this caſe, Tab. V. fig. I. the teeth *b* immediately appear behind that skin *a*; and in a boiled Snail they are rendered very viſible, Tab. IV. fig. IV. *r*, becauſe the skin and lips become thus contracted. Theſe teeth are connected by a certain horny concretion, Tab. V. fig. II. *a*, the teeth themſelves being all made of a horny ſubſtance; and they are of a light red colour. Since therefore all theſe teeth are connected one with the other, they ought to be eſteemed, in ſome meaſure, as one tooth. They are eight *b* in number, and ſome are larger and more prominent than others, as appears by the microſcope. This little part is made in the form of a circle *c*, its convex ſide lying on the inſide upwards, towards the ſkin, to which it is ſtrongly connected; but its toothed concave ſide, with which it bites, is directed on the outſide. In the middle of the convex ſurface of this tooth, there is a ſmall furrow, in which ſome of the muſcles that move the whole are fixed. The tooth afterwards becoming inſenſibly membranaceous, expands itſelf like a pretty large pyramid or bodkin, fig. I. *c*, and in that form conſtitutes a great part of the palate, which, on each ſide of this expanſion, is beautifully variegated with ſmall ruddy points: theſe here and there ſhew little parts that are ſomewhat hard, and of a horny ſubſtance, and ſerve to prevent the inward part of the body from being wounded or hurt, in caſe the Snail ſhould at any time ſwallow any thing too hard or rough. But this cannot be ſeen, unleſs the inward parts of the mouth be firſt diſſected, and taken out ſeparately. Then two ſmall, narrow holes or apertures *d* are ſeen on the upper and under part in the palate, which convey the ſaliva out of its ducts into the mouth.

In the lower part of the mouth, or where our lower jaw is placed, are, in the Snail on the fore part, two ſmall fleſhy ſubſtances *e*, which may be called the inward lips, for they contribute greatly to direct the paſſage of the food; that is, to carry it towards the gullet, and thruſt it down. Behind theſe, a certain very delicate and tender membranous crooked cartilage preſent ſents itſelf to view; at the loweſt and inward part of which the tongue, Tab. V. fig. III. *a*, and its muſcles take root. The tongue itſelf lies under the concave fold or winding of this cartilage, fig. I. *f*, and is covered therewith when the Snail ſwallows its food, juſt as the epiglottis in us covers the top of the aſpera arteria or wind-pipe, when we are eating, leſt any thing ſhould ſlip into the wind-pipe. This texture of the tongue in the Snail approaches yet nearer to that of the tongue of the Serpent kind, which in the ſame manner ſhuts itſelf up in ſuch a cavity. The tongue of the Snail is thus placed in a remarkable cavity, and its baſis or root lies in the cavity of the neck towards the belly, where it is obſerved to ſwell like a ſpheroid or oblong globe, fig. III. *b*; but a little on the inſide of that part where the tongue appears, there is ſeen a very delicate muſcle, which draws the tongue together with the whole mouth, palate, jaws, and even the brain itſelf, inwardly into the belly, or at leaſt into the neck. See Tab. IV. fig. VI. and Tab. VI. fig. II, *e*, *f*, *g*.

On the tip of the tongue of the Snail *c*, there is a little horny bone, cut, as it were, into two or three very tender little teeth; with which, as with a hook, the Snail, when it is about to eat, firſt lays hold of the ſmall herb, and immediately after ſuddenly ſnatches and pulls the piece into its mouth; afterwards it nips them pretty faſt with its teeth, ſo that the noiſe it makes in biting and eating may be ſometimes heard very diſtinctly. The Snail will ſometimes ſwallow a piece as big as an hemp-ſeed. Theſe parts of the mouth have three muſcles remarkably delicate, by the aſſiſtance of which they are, at the creature's pleaſure, moved out of the cavity of the body. Theſe muſcles are fixed in the lower ſide of theſe parts *d*, which are repreſented invertedly in this figure. As theſe creatures are moſt immoderate devourers of vegetables, the keepers of vine-yards in the wine countries anxiouſly gather them, when the vine puts forth its tender buds and firſt leaves, and tread them under foot. This I have ſeen tranſacted as a work of great conſequence in France. We may therefore reckon Snails as a part of the hoſt of God, wherewith he can chaſtiſe bad people in the ſame manner as he did the Ægyptians, with voracious inſects of the ſame nature.

C H A P. III.

Of the taſte, ſmell, and certain actions of the Snail.

I For a conſiderable time kept in my chamber, and provided with neceſſary food, ſeveral Snails: theſe were incloſed in a box, placed in a wooden bowl, and covered with a mat full of holes, through which they could ſtretch their necks, that I might be able to find out their manner of acting, and ſometimes view them with a microſcope. I fed them with radiſhes, lettuces, ſorrel, mallows, and other ſucculent and dried vegetables, which, after keeping them a little in water, I gave them freſh every evening; for they naturally eat in the morning and evening, and they love juicy and freſh herbs much better than old and withered ones. From this I obſerved, that they had a nice appetite and taſte, as well as other creatures, for which purpoſe they have alſo guſtatory nerves.

They have likewiſe a very quick ſmell: this I obſerved, when I moved a little freſh food towards them, for they immediately perceived it by the ſcent, and crept out of their little ſhells and came to it. Thus they were kept alive; but as they were in a dry place in my chamber, I at length obſerved they did not thrive there for want of dew and rain; nay, that ſometimes they loſt their appetite, ſince they would lie contracted within their ſhells, and were hidden entirely in their horny ſkin. But I at length found out a method of giving them rain, as it were; which I did, that they might come into the light again, and ſeek ſuch food as I laid before them. From this I obſerved how little we are able to do by our own boaſted powers; who, from our very miſerable infirmities, cannot, I will not ſay, make, or even accurately examine, but ſcarce can with our beſt diligence give theſe animals due food or nouriſhment.

In order to give them water in the manner before mentioned, I made uſe of a braſs tube, to which was annexed, by a worm, a ſmall globe of the ſame ſubſtance, which was pierced with fine ſmall holes, and had been originally made for the purpoſe of watering ſome plants, for feeding other inſects. This machine forms a very beautiful kind of rain, that falls in little drops. As ſoon as the Snails feel this little rain, they immediately begin to creep: in the mean time, it is pleaſant to ſee with what velocity they can turn in their little horns, and hide them in the inſide of their body, as ſoon as the little drops fall upon them; ſo exquiſite a ſenſe have they in theſe tender parts, and indeed the whole body. This creature is very timorous, and retires into its ſhell, when it finds itſelf diſturbed by the leaſt thing that it is not uſed to. If it be ſtruck or handled, it not only retires very haſtily into its ſhell, but it immediately covers its whole body with a glutinous moiſture.

Whether Snails have the ſenſe of hearing, I could not diſcover by experiment; indeed, I have not obſerved any ſign of it in them, though I have made a very loud and harſh noiſe about them. I find, however, that many creatures, to whom authors have denied this faculty, enjoy it perfectly; for example, the Camelion. I have likewiſe obſerved that Frogs and Fiſhes have this ſenſe; nay, Fiſh have a wonderful labyrinth of the ear for that purpoſe.

CHAP. IV.

Of the ſtructure and uſe of the verge or lip of the Snail, and of its reſpiration and voice, with other experiments: alſo of its glands, veſſels, and what it has in the place of feet.

HAVING deſcribed the eyes, mouth, and teeth, and treated of the ſmell and taſte of the Snail; it is proper I ſhould now treat of the aperture, through which the parts of generation occaſionally diſcloſe themſelves. This I ſhall conſider, when I come to ſpeak of thoſe parts themſelves, but previouſly to that, I ſhall ſay ſomething of its lip, or the fleſhy verge at the head, and of the apertures in it, as alſo of the fringed margin of the body, and the little excreſcences viſible on thoſe parts, and of the veſſels that run between them.

Tab. IV. fig. I. The verge that ſurrounds the whole body of the Snail is not ſo broad within as on the outſide, and is connected very cloſely to the extremity of the ſhell both inwardly and outwardly. As this is provided with a great number of muſcles, it accordingly acts with various motions, ſuitable to the different intentions of the Snail. Hence it is, that its true figure cannot be determined, for it is continually contracting, expanding, and changing its form. Where it is annexed to the upper part of the Snail's body, it exhibits two ſingular inciſions like two little tongues; and underneath the right ſide of the belly, it has a remarkable aperture, Tab. IV. fig. I. *g*, which ſerves to take in air; beſides which, it has another *f*, whereby the fæces or excrements are voided, as if by a ſmall, oblong and curled inteſtine. The colour of this verge is white, with certain yellow ſpots, grounded, as it were, on a pale tranſparent green. On the inſide, where it is joined to the ſhell, it is of a blackiſh colour, ſomewhat approaching to blue. It has different uſes, as appears both from what has been hitherto ſaid, and from what I ſhall hereafter obſerve, when I come to treat at large of the Snail's bone.

On the inſide, this verge is arched, as it were, and reaches with its cavities upwards, towards the pointed extremity of the body, to the windings of which, theſe cavities are adopted. Above, in the inward ſurface of the border, there are ſeveral veins, Tab. V. fig. IV. *a*, which run there naked or uncovered. But below in its cavity, almoſt underneath, on the left ſide, and in the declivity of the body, is placed the heart *c*, which may be ſeen to beat, even through the external ſkin, before that part is taken off: I have therefore marked its figure from the origin with points, Tab. V. fig. IV. *l*. This heart and its veins are continually refreſhed with the air, which the Snail impels into it through the aperture of its verge, Tab. V. fig. IV. *b*: for as the Snail rolls its body out of the ſhell, ſo in proportion it drives the air into the cavity of its verge; and again, according as it draws back its body into the ſhell, ſo it likewiſe expels the air from thence. This may be eſteemed ſomething analogous to reſpiration, as I have ſhewn in the year 1667, in my treatiſe on that ſubject, and exemplified particularly in the caſe of the garden Snail.

When the Snail has crept out of its ſhell, and is put into water, the air contained in the cavity of this verge makes it ſwim on the ſurface; but when the Snail is within its ſtony ſkin, and the cavity of its verge is cloſed and compreſſed, it ſinks to the bottom, if it be thrown into the water. But if the Snail, as it lies in the water, creeps again out of its ſhell, the cavity of the verge is immediately filled with the water ruſhing into it, which then does the buſineſs of air, which would have been impelled thither; hence it happens, that by a new kind of reſpiration, this water is ſometimes moved within and ſometimes without the ſhell, according as the Snail rolls its body out, or draws it into it.

The Snail has no voice, nor makes any noiſe, except that it produces a kind of hiſſing when touched with a ſtick, or any thing elſe, and ſuddenly draws in its body; for then, as the aperture through which the air is conveyed, is in a manner ſtopt up, it cannot readily get out; and this cauſes the hiſſing ſound.

Sometimes it happens that, do what we will, we cannot get the Snail out of its ſhell, in order to make this experiment, by which we might ſee that the air is forced into and out of the body, through the aperture of the verge. But if you have a mind to make the experiment, and obſerve in what a wonderful manner this aperture then ſhuts and opens itſelf, you muſt ſtrike the ſhell a little on the hinder part with the back of a knife; then immediately the Snail, compelled to it by the pain that it feels, will creep forward, and will plainly ſhew the opening through which the air paſſes, together with the manner of its reſpiration.

The extreme fringed margins of the body are planted as it were with numerous glandular tubercles or excreſcences, Tab. IV. fig. I. *bbb*, from which the mucus or ſlimy moiſture iſſues. Theſe tubercles are covered with a great number of veſſels, which run between and furniſh them with matter for the ſlimy humour. Theſe glands project beyond the ſurface of the skin, and are covered as it were with white tranſparent points, between which, as between ridges, or in furrows, the veſſels are ſeen to creep. This order is contrary to that which the all-wiſe Creator of the world hath choſen in the leaves of trees; for in the latter, the veins and nerves are uſually ſomewhat prominent, and the ſucculent part is depreſſed and placed between them.

The greateſt part of the ſubſtance of theſe fringed margins conſiſts of three membranes. The firſt and uppermoſt of theſe is a glandular skin; the middle one is a glandular, but thin, membrane; and the loweſt is a ſomewhat thicker membrane ſmooth and ſlippery. Under theſe the body of the Snail is interwoven with ſtrong muſcles, by the help of which, and with a ſingular kind of motion, reſembling, as it were, the waves and billows of the ſea, it moves at pleaſure its ſhell and whole body. Theſe fringes therefore perform the office of feet in this little animal, and they may be properly called the general foot of the body. This whole part is tender and ſpungy; yet, when it is pricked wirh a needle, it can contract its muſcles with ſo much force, that it draws up and joins itſelf together, ſo as to become as hard as leather.

The part of the body which lies under theſe is very white, and is covered with an even skin, which ſeems to me more tender than the former; but it is glandular like that, and is fitter for motion, by reaſon of its fineneſs. If the Snail be ſuffered to creep, this motion may be obſerved very beautifully; for if the glaſs be inverted, as the Snail is creeping on it, this admirable motion will be perfectly conſpicuous: it reſembles ſmall waves, which, when agitated with a gentle wind, ſlowly follow each other; nor can I explain this motion by a more proper example.

As to the motion of the animal ſpirits being obſerved, like ſmall globules moving from the head to the tail, and again from the tail to the head, in a naked Snail thrown into the water; it is indeed a mere chimerical notion, invented by thoſe philoſophers who make no experiments to guide them, but grow pale over their books only. The reaſon of the appearance which gave birth to the opinion, is this, that when the Snail is thrown into the water, ſome air always remains fixed in the mucus of the body, which never ſhews any regular or determinate motion, although it really has a very ſtrong one; for the little bubbles always retain their order and ſituation among themſelves, though they are contracted and expanded with the body; that is, they are heaped one upon another, and again ſeparated from each other from time to time.

CHAP. V.

Of the actions, and of the ſtrength and life of the Snail. How it is to be killed for diſſection, with further experiments; and an account of the effect ſalt has on this creature.

WHEN Snails are diſpoſed to reſt, ſo as to remain quiet without any motion of their verge or foot, they diſcharge a great quantity of ſlimy matter from their bodies, which, when dried, anſwers the purpoſe of a couch or hammock, in which they reſt. This they do in the day-time, and they will lie in this manner as long as it rains, or the atmoſphere continues cool; for nothing diſtreſſes them more than drought.

From this we learn alſo, that their ſlimy humour, which, at other times is clear and white, is more coloured, or has greater variety of tincts, the leſs of it they have in their veſſels and glands.

Theſe creatures are very fond of company at the time they are increaſing their ſhell, for then hundreds of them gather together in ſhady places, that they may be at leiſure for that buſineſs, lying quiet and cloſe to each other, eſpecially for ſome days before they begin to copulate; as I ſhall ſhew in its proper place.

Life is very ſtrong in them, inſomuch that they will live ſix or ſeven days under water. Nay, if they are wounded, and even dragged from their skin or ſhell, they will ſtill live four days, provided they are put into water. They are ſo ſtrong, that they can very eaſily creep forward, and move themſelves to all quarters, with another Snail ſticking to their ſhell; nay, one will ſometimes draw two others. The period of their natural lives cannot be certainly determined, but I am inclined to think they live to a very great age, which may be probably conjectured from the ſlow increaſe of their ſhell: on the ſurface of their ſhells are ſeen a very great number of the ſame kind of marks, Tab. IV. fig. 11. *s*, obſervable in a cow's horn, from which the country people compute the age of that creature.

The diſſecting Snails has coſt me great labour; for this operation is very difficult, and muſt be performed whilſt they are living. If we ſprinkle the Snail with ſalt, it is not conſumed, as is generally thought, but only killed, and then the ſtrong contraction of the muſcles draws up all the internal parts to ſuch a degree, that nothing can be ſeen diſtinctly. All the ſlimy humour is then diſcharged out of the body; ſo that I obſerved, that the ſpermatic parts themſelves were rendered three times ſmaller in this ſpecies of Snails, which is indeed very worthy of obſervation. Salt therefore ſeems to me to be a matter proper for cleanſing the Snail, for by this means all its humours are diſcharged. The inſect might otherwiſe be rubbed over with ſome purgative medicines, in order to try what effect they would produce; and, indeed, the ſucceſs of ſuch an experiment would be of ſome uſe in the medicinal art. I have often reſolved but have not had opportunities to try it. I think that the act of purging in our inteſtines is performed in the ſame manner, that this effect is produced on the outſide of the Snail; for the acrid, pungent, and provocative ſtimulus, irritates all the glandular parts of our inteſtines; and theſe parts are ſituated on the skin of the Snail, whereby they throw off and diſcharge the humours contained in them; and at the ſame time waſh away, as it were, every thing they find offenſive. This is manifeſt in the ſaliva, which is copiouſly diſcharged from our ſalival ducts, when any acrid and ſtimulating remedies are held in the mouth. This any perſon may experience very clearly, if he chews the roots of pellitory of Spain.

I cannot therefore agree that purging is peculiar only to a few particular medicines, which the practice has ſelected for that purpoſe; or that particular humours are expelled from the body, by ſuch as are commonly called ſpecific purgatives; as if theſe knew, from reaſon and judgment, how to diſtinguiſh water from phlegm, and the latter from all other ſuperfluous humours; and to ſecrete this only, and throw it out of the body. Whereas, it is more agreeable to experience, that, that matter only is diſcharged, wherewith the body abounds moſt, and which is more than any other copious in its veſſels at that time. If this be ſo, it will be ſufficient to obſerve, in regard to purgatives, whether they be hot, dry, cold, or moiſt; nor will there be any further neceſſity to load the memory with new-invented names and fictitious diſtinctions.

It is improper to put Snails into ſpirit of wine, oil of turpentine, or any other ſuch liquors, in order to kill them; and though I have ſometimes killed other inſects with the vapour of lighted ſulphur, that they might remain whole for the diſſection; yet I have fancied the fitteſt and beſt contrivance for this purpoſe, is to kill the Snail ſlowly, or by degrees, by keeping it under the water. This method is attended with this great advantage, that the Snail never contracts its muſcular parts; which, on the contrary, are beautifully expanded: for the water penetrating into the orifice, of its glands, mixes with the ſlimy humour there, and, at the ſame time, by dilating, ſurpriſingly expands the whole body. Hence I have found that many parts, which otherwiſe are hidden, or cannot be inveſtigated, but by great labour, become viſible with great familiarity, as the aperture of the genital organs with the penis and uterus, the teeth alſo, and the form of the verge or extremity of the body, the glands and other parts are all rendered conſpicuous on account of the water contained in them; the Snails are, therefore, by this means, rendered fit for diſſection.

Some curious perſons feed this kind of Snail in their gardens, and at their country ſeats, as I remember to have ſeen at the Hague and Culenburgh, in the kitchen gardens of the illuſtrious counts Maurice and Waldeck; and in many other places, particular in grotto's, which are adorned with ſea productions. The propereſt time for removing theſe Snails is in the winter, for then they lie cloſe in their ſhells without motion, and are defended therein by a particular kind of operculum, or cover, formed by a hardened quantity of the ſlimy moiſture vented for that purpoſe, which very exactly cloſes up the entrance into the ſhell. If they are to be ſent from place to place in ſummer, the beſt way is to ſend them wrapped up in a quantity of freſh herbage; when they are deſigned to be eat, they ſhould be put into a bag, and chopped ſtraw ſcattered between them, by the pricking of which they are prevented from creeping out of their ſhells.

CHAP. VI.

Of the internal parts of Snails; and firſt of the heart, its auricle, the vena cava, and aorta. And alſo of the blood, and its perpetual circulation. Of the difference of the ſlimy humour from the blood. Of the cavities of the verge, and alſo of the ſacculus calcarius, or bag of alkaline matter. To which is added, a curious experiment, pertaining to the motion of the muſcles.

AS I have hitherto been taking a ſurvey of many of the external, and of ſome of the internal, parts of the Snail, I propoſe to go on now to a deſcription of its ſhell: but then it will be moſt proper to diſcourſe of that, after I ſhall have deſcribed thoſe parts, from whence the ſhell itſelf derives its nutriment and growth. As I have already gone through the examination of the principal internal parts, I ſhall not confine myſelf rigidly here to the order uſually obſerved by anatomiſts, who commence their inquiries with the belly or head; they do this to get rid of thoſe parts, which would firſt taint; but no noxious ſubject is to be feared in this caſe, and the animal itſelf being ſmall, I have choſen rather to treat firſt thoroughly of thoſe parts, which were firſt obvious to me. Neither need I be uneaſy, if I have delineated one part ſomewhat larger, and the other ſomewhat leſs; the microſcope not admitting of greater accuracy: and indeed this avails nothing in our attempts to inculcate a knowledge of the ſubject, unleſs ſome particular points may be more diſtinctly underſtood, if on that occaſion, the parts are exhibited a little larger than the life.

The beſt manner of diſſecting the Snail is, the ſhell Tab. IV. fig. II. *i*, being pulled off, to begin at the verge of the body, fig. I. *e*; which alſo ſhould be cut off from the left ſide, with a fine pair of ſciſſors; in the doing this, taking care not to pierce the apertures *g*, ſituated on its right *f*, theſe ſtill remaining unhurt, the verge is to be ſeparated from the body, which viſibly adheres to it below; for otherwiſe, unleſs theſe apertures be carefully avoided, the outlet of the inteſtines, and the paſſage of the alkaline bag, will be equally injured.

In this management, what firſt meets the eye, is the skin of the ſubjacent body, which is concealed by the upper and under part of the verge, or a membranaceous ſubſtance, as with a covering, being much more delicate about that place, and of a whitiſh or paliſh colour, and compoſed of oblong muſcular fibres. If you have nicely ſeparated this part of the internal skin, you will ſee the tranſverſe muſcles lying under it; which, though not altogether colourleſs, are in ſome degree tranſparent; and on both ſides, in the ſoft or bending part of the belly, there will be obſerved certain muſcles reſembling a ſaw, which ſtretch their tendons above the peritonæum; but the ſmall muſcle, running tranſverly, is ſituated above the peritonæum, under which it lies. All theſe muſcles ſerve to preſs the body inwards, and to move forwards the contents of the inteſtines, and of the ſpermatic veſſels.

But if after this the verge, together with its membranaceous parts, be drawn backwards over the bending of the body, and then cut off from the place where it adheres, then immediately appear the veins, Tab. V. fig. IV. *a*, which run beneath toward the verge *b*, and the heart *c*, with its auricle *d*, and the vena cava juſt dawning out of it; together with the various cavities, in which the air is moved, and ſome other ſmall parts beſide, ſuch as the alkaline bag *e*, and its duct lying next to the inteſtine, the inteſtinum rectum *f* itſelf, the liver, and certain parts belonging to the ſpermatic veſſels. Some of theſe I ſhall now deſcribe in their order, and of the others afterwards in their place. Firſt, of the heart.

The heart is ſituate in the middle of the Snail's body, near the extremity of the arch of the verge, which ſurrounds the whole body; and at that place, a little to the left, in the bending of the body, by reaſon of the thinneſs of the inteſtine membranes, which are perfectly tranſparent, Tab. IV. fig. I. *l*, it is diſcerned moving. It is included in an extremely thin bag or pericardium, in whoſe cavity there is ample abundance of watery moiſture, as clear as the pureſt chryſtal. The pericardium being diſſected, immediately appears the beating heart, Tab. V. fig. IV. *c*, with its auricle *d*; which, being of a membranaceous and exceeding delicate texture, is ſeen to be interwove within, with divers as well fleſhy as membranaceous fibres, in the ſame manner as is ſeen in the auricles of the heart of a man, and other animals. The heart itſelf is of a fleſhy ſubſtance, and of a pale reddiſh colour, exhibiting a muſcle, which for the ſpace of a day will continue waſting away into water, and yet not be cleared from all its blood. The external ſuperficies of the heart is ſmooth, and it is ſhaped like a pear; but the internal parts are uneven, with ſeveral fleſhy columns, hairs, and fibres, much the ſame as we obſerve in the hearts of men and brutes: hence it is that the heart may be eaſily diſtinguiſhed by the many ſinuſes and angles in it, and it is very fibrous. At its entrance, near the auricle, there adhere two little ſemi-lunar valves *c*, which ſerve to hinder the blood from returning into the auricle. But as there is only one auricle to the heart, ſo is it only found in one cavity; and agreeably to this, there are alſo found two kinds of veſſels there, namely, the veins and arteries. The veins, above the auricle *d* of the heart, are conſpicuous without much pains, and in particular the vena cava may be obviouſly ſeen; out of which others, juſt ſpringing forth, are interwoven amongſt one another after a ſurpriſing manner, and form an elegant kind of net-work. The arteries are not diſcovered without greater difficulty, nor can they ever be ſeen, but at the firſt opening of the body. The beginning of the aorta, or great artery, is about that place without the belly, where the heart is united to the calcarious bag *e*; and the great artery derives its origin from the cone, or more acute extremity of the heart, and is a little dilated, at its very beginning, as is common in fiſhes; immediately from this part it diſperſes its ramifications every way, both through the internal parts of the body, and outwardly among the membranes, equally backward to the ſpire, and forward; firſt, indeed, reſpecting thoſe parts it borders upon, namely, the calcarious bag *e*, the inteſtines, the liver, the ſtomach, and the ſpermatick veſſels; then immediately proceeding to the coat inveſting the liver, and then to the muſcles, nerves, and little glands of the skin. I have delineated *h* ſome of the more remarkable ramifications, only with their diviſions, and have marked the reſt of its body, and its ſpiral ſhape, with points *iiii*, that the ſituation of theſe parts might thence be underſtood.

The blood contained in the heart, and its arteries, appears of a whitiſh colour, inclining ſomething to blue; and hence it differs very much from that of men and brutes; for the blood of all thoſe is of a deep red; but, as the blood in ſmall animals, excepting thoſe only which live in the bowels of the earth, as many as I have known of them, want that purple colour; for this reaſon then authors, who are only wiſe in their own ſpeculation, have called them animalcula exſanguia, or animalcules without blood, though even in ſome human bodies, there has been obſerved ſometimes white blood in the arteries. The blood of the Snail is of a glutinous conſiſtence, clammy, and pituitous or phlegmatic; if poured into water, it ſhews itſelf like a sky-coloured cloud, which gradually expands, and grows more and more tenuous, and at length quite vaniſhes; and is indeed a very pleaſant ſight.

The blood which remains from the nutrition of the membranes, returns through many extremely ſmall veins toward the heart, there to undergo a new concoction. Theſe veins are chiefly ſcattered about the external parts of the body, and are there very conſpicuous; for thoſe veſſels which we ſee there, are almoſt all conſpicuous, as they may be ſeen among the pointed little glands of the verge. All theſe veins converge in one large trunk called the vena cava; which, as we have juſt ſaid, may very plainly be ſeen on the internal ſuperficies of that arched membranaceous part of the rim or fringe of the Snail, Tab. V. fig. IV. *b*; for the veins run off, under and through this verge or fringe, and afterwards diſcharge their contents into the auricle *d* of the heart; which then, by its contraction and ſyſtole, again protrudes this blood into the heart *c*; and the heart, with a manifeſt circulation, again ejects it into the arteries, and thoſe again into the veins; that the motion may never be interrupted, but the blood maintain its courſe through the body. Hence the pulſation of the heart is firſt diſcerned in its auricle; but afterwards in the heart itſelf; thoſe veins which ſpring from the vena cava, are formed and diſperſed with ſuch wonderful artifice, in the aforementioned membrane, that I have determined to ſet forth an accurate drawing of them; to the end, that the works of God may be ſo much the more clearly underſtood, and more firmly impreſſed on the memory.

The heart, with its auricle, is never more diſtinctly ſeen, than when it is cut open through the vena cava, diſtended with a blaſt, and then half dried; but if it be dried too much, it is leſs forcibly contracted; and its internal fabric and ſmall valves cannot be ſo conveniently viewed. But ſeeing theſe veſſels all contain a whitiſh or lightly-coloured blood, from which they may be eaſily taken for nerves; it is therefore expedient that they be firſt filled with an injection of ſome coloured matter; which operation, by reaſon of the exceeding ſmallneſs and fineneſs of thoſe parts, is indeed a very curious and difficult task.

For thoſe who delight to engage in ſuch a proceſs, there are colours of that ſort which ſubſide; and thoſe ought to be mixed with ſo fine a liquor, that it may paſs through the pores of the veſſels, and fly off into the air. But if any one uſe a liquor of a ſimple colour, then they will be all of one tinge, nor can any thing be diſtinctly exhibited to the eye. I might explain many of the operations and artifices requiſite to the perfecting this matter; but this part of the work, beyond my expectation and deſign, has grown redundant enough under my hands already.

The difference between the blood and the ſlimy humour in the Snail is very remarkable, and may be obviouſly known only by the colour and conſiſtence; for though the blood is thin and fluid in the veins, it becomes tenacious after it is taken out of thoſe veſſels. Nay, although it be immediately thrown into water, it does not mix therewith, unleſs it be ſhook a little. On the other hand, the ſlimy humour ſecreted by the glands, takes a long time before it is diſſolved in water, becauſe it is tenacious and thick; and this is of a white colour, and may, therefore, by thoſe qualities, be eaſily diſtinguiſhed from the blood; whenever the wounded Snail is thrown into the water, in order to mix the blood and this ſlimy humour with it.

The blood, being laid upon white paper, leaves no gloſs; whereas the ſlimy humour covers it, as it were, with a bright varniſh, like ſilver; it may therefore be mixed with colours, to give them a gloſs. Thoſe, who eat Snails, eſteem their blood very highly, and call it their liquor, taking particular care that it ſhould not be loſt; and I think they, as well as thoſe who eat oyſters, have ſome reaſon for ſo doing.

After what manner the ſlimy humour diſtils from the glands of the ſkin, may be ſeen in this manner; the ſkin muſt be wiped with ſpungy blotting paper, until none of the ſlimy humour is ſeen, or till the whole is cleared off; then the ſkin muſt be taken between the fingers and preſſed gently; and if this be done under the microſcope, the ſlimy humour will be ſeen to come out inſenſibly, from the glandular pores of the ſkin, like clear and minute points; theſe, by continuing the preſſure, will become ſmall drops; and theſe, in ſome time gathering together, will form a conſiderable collection of this matter; ſo that the whole ſkin will be moiſtened, and become glutinous.

The cavity of the arched verge, in which the air moves, forms a round bow or arch, occaſioned by the membrane's expanding itſelf againſt the ſhell; but this happens only when the Snail lies in its ſhell; for when it is taken from thence, the membrane of the verge immediately ſlips into the parts underneath; ſince it is no longer ſuſtained by this ſupport againſt the ſhell, being connected to the latter only by the toughneſs of the mucus, or ſlimy humour. If this membrane be again ſwelled up from its aperture for air, it will be obſerved to expand itſelf very beautifully againſt the ſhell. This cavity in the right ſide of the body reaches to the turn of the inteſtines; but in the left ſide, where the heart is ſituated, it goes according to the windings of the liver, and follows the turnings of the latter, unto the third and ſecond convolutions of the inteſtines in the body.

In this arch of the Snail's verge, near to the heart and its auricle, there is ſeen, Tab. V. fig. IV. *e*, a certain oblong, triangular little part, to which the heart *c* is fixed and united, there being nothing between them but the pericardium. But on the outſide it ſwells, Tab. IV. fig. I. *n*, through the ſkin; and is very viſible in a boiled Snail, when taken out of its ſhell, fig. IV. *o*. This latter likewiſe ſhews the figure of the body at that time, that is, the convolutions *p* of the liver, and after what manner the verge contracts itſelf *q*. The colour of this little part is like that of grey aſhes mixed with water. On the hinder part it is connected, Tab. V. fig. V. *l*, very ſtrongly with a certain part of the inteſtines and liver; but that part of it which is ſeen through the outmoſt membrane which covers the body, is obſerved to be interwoven with many veſſels. On the other ſide, its colour is more wateriſh *m* than where it is of an aſhy-grey, and connected to the pericardium *k*.

I firſt thought that little part was the ſpleen, but when I viewed it more accurately, I obſerved that it diſcharged itſelf into a pretty large duct, which runs near the inteſtinum rectum, or ſtraight gut, fig. IV. *f*, and in my opinion opens into it. I therefore now believe this part to be a glandular little body, or a ſacculus or bag, whereby the calcarious matter of the blood is drained from the body, and depoſited in the inteſtinum rectum, or ſtraight gut; and accordingly we find that ſuch a matter is there ſometimes mixed with the excrements. If this little part be diſſected, and put into water, it exhibits a glandular ſubſtance; but as it abounds with a grey calcarious humour, it makes the water muddy. On the ſide oppoſite to the inteſtine it appears ſomewhat bright; and ſeems to conſiſt of a glaſſy ſubſtance; it has the ſame aſpect in ſeveral places; alſo in the middle, where it ſeems divided into little grains, which are viſible underneath: it taſtes like aſhes.

CHAP. VII.

Of the liver, bile, ſtomach, inteſtines, and ſalival veſſels of the Snail.

THE liver, which for the moſt part lies in the hinder portion of the ſhell, forms a ſpiral convolution there with the inteſtines, Tab. V. fig. VI. *a*; as may be ſeen on the outſide, Tab IV. fig. I. *k*. It is further divided into divers lobes, Tab. V. fig. VI. *bbb*, according to the different courſe of the inteſtines, which make as many diviſions in it, as they have turnings and windings. Beſides theſe, the liver is very full of greater and ſmaller veſſels, which are diſperſed through every part of it, fig. IX. *a*. It has likewiſe its particular thoracic or chyliferous ducts, fig. VIII. *a*, which diſcharge themſelves into the inteſtines, without any intermediate gall-bladder; in the ſame manner as in Horſes, Pigeons, and other animals, which are ſaid, though without any foundation, to have no bile. I could perceive no remarkable bitterneſs in the bile of the Snail.

The liver itſelf ſeems to conſiſt of ſmall equi-diſtant little grains, called glands by the great anatomiſt Malpighius; to whoſe judgment we ought to give great credit, ſince one can ſcarce find his equal in anatomical knowledge. The liver is of a dark brown colour, a little approaching to green: the hardneſs and ſubſtance of it, are like thoſe of the ſpleen in a man. It abounds with a juice or humour of a yellowiſh green colour. In the upper part, where the liver turns round, its outward coat, which is covered with little whitiſh points, grows greener. It has very few lobes on the inſide. Nothing is more ſavoury in a boiled Snail than the liver, which, I think, is alſo very eaſy of degeſtion: whereas, on the contrary, all its muſcles are hard and tough, except the ſpermatic veſſels, which are likewiſe very pleaſant eating.

The Snail's ſtomach, fig. VI. *c*, is placed in the cavity of the neck and belly, and conſiſts, as in man, of three coats, notwithſtanding its being very tender and thin: it is alſo provided with veins and arteries. It is of a white tranſparent colour like parchment; but when diſtended with food or air, it has the colour of the moſt tranſparent membrane: when empty, it appears full of oblong grooves, Tab. V. fig. IV. *n*, which exhibit an agreable ſight; for they are ſo many contracted muſcles, which corrugate the coat in this manner. The ſtomach grows narrow by degrees, fig. VI. *d*, and forms by that contraction its lower orifice, called the Pylorus. After this follows the ſmall gut *bbb*, between which the liver is principally ſituated. After theſe inteſtines have turned themſelves two or three times, then they form the inteſtinum rectum, or ſtraight gut *e*, which opens, with its foramen, into the Snail's verge *f*. About the ſpiral convolution of the body is obſerved *g* a place, where the bile diſcharges itſelf into the beginning of the inteſtines; which appears more evidently, if thoſe biliary ducts are ſomewhat ſeparated, fig. VIII. *a*; ſo that the whole region of the ſtomach *b*, ſmall *c* and great guts *d*, be parted from the liver. If the inteſtines and the liver be inverted, ſome of the parts before-mentioned may be ſeen more diſtinctly; that is, the liver itſelf, fig. VII. *a*, and the ſmall guts in their natural ſituation *b*; then the inteſtinum rectum, or ſtraight gut *c*, and the ſtomach *d*.

And here we muſt obſerve, that two very beautiful veſſels run, fig. IV. *oo*, along the ſtomach and the gullet, or œſophagus, which diſcharge themſelves into the upper part of the palate of the mouth, fig. I. *d*. Theſe veſſels are of the ſame ſtructure with that part of the epididymis in man, which lies upon the teſticles, and they are of the colour of an agate. On the inſide they are hollow and contain a clear liquor, which they diſcharge by two ſmall apertures which open into the mouth. They are, therefore, plainly the ſalival ducts of the Snail, ſuch as are likewiſe obſerved in man and brutes, and are ſituated either near the ſame place, or a little lower.

Theſe two little veſſels ariſe from two ſmall, clear, and ſnowy parts, fig. IV. *pp*, joined together in the middle, and divided into various little lobes: you would eaſily believe that they were nothing more than fat. A beautiful little veſſel *q* runs through the whole ſurface, which brings them nouriſhment and moiſture, and, ariſing out of a very high place under the verge, where the body begins to bend, comes to this part, and gives a great many branches to each of theſe ſmall parts. Theſe little parts are likewiſe, by the help of different veſſels, which ſeem to be ſo many ſmall and tender filaments, laterally connected with the ſtomach. The ſalival ducts themſelves are, by certain ſingular veſſels or ligaments, alſo connected with the ſtomach. I firſt indeed thought that this ſmall part was the pancreas, but experience has taught me the contrary, and likewiſe that it is not fat; for it cannot be melted by fire, nor is it inflammable, if put on a bit of glaſs and applied to a lighted candle.

CHAP. VIII.

Of the genitals, penis, uterus, teſticles, ovary, and other parts ſubſervient to generation.

THE ſpermatic veſſels are placed not only in the fore part of the neck, belly, and back of the Snail, but being twiſted like vine tendrils, follow the convolutions or windings of the body itſelf, and extend themſelves to the extreme end of the liver; ſo that they may be juſtly reckoned amongſt the moſt remarkable parts of the body. Before they can be ſeen, the ſkin muſt be diſſected, and ſome of the membranes and muſcles removed; and among the latter there is a very elegant muſcle, which, with many fibres, reaches obliquely from one ſide of the body to the other, and ſhews itſelf beautifully upon the ſtomach, and thoſe parts that ſerve for generation.

The male and female organs of generation are both in the ſame Snail, and the penis and uterus, being naturally united, grow firmly together; ſo that many of the parts are common to both. The ſmall parts, from the ſtructure of which it is known that they belong to the male organs, are the penis, Tab. V. fig. x. *a*, with its ſharp, twiſted, oblong appendage, which, at the extreme end, is round, in the form of a pear *bb*. To the female parts belong the uterus *ccc* and its ovary *dd*, which opens into the cavity of the uterus; that the little eggs may be increaſed and covered with moiſture therein, as may be ſeen very beautifully in the Ray-Fiſh; nay, and in ſome degree, in the uterus of Hens. But in other animals, as in Tortoiſes, Lizards, and Camelions, there is found a greater agreement in this reſpect, with the Snail, than I could obſerve in fowls.

As to the parts which have a mutual communication among themſelves, to theſe may be referred the teſticles: theſe are, as it were, a congeries or heap of oblong filaments *e*. Then the hidden appendages of the uterus *f*, and a certain common duct between the penis and the uterus, Tab. V. fig. x. *g*. Afterwards there is an oblong vas deferens, which opens at the end by a ſmall tube into the uterus *i*, and has a little ball in the form of a pear at its extremity *k*. Laſtly, there is a very beautiful curled veſſel *l*, of the ſame ſtructure with the epididymis in man and quadrupedes, which being twiſted in, like a little chain, diſcharges itſelf by a ſmall tube *m*, into the beginning of the uterus and end of the ovary.

Having enumerated theſe things in general, I ſhall now treat of each part in particular, and aſſign the reaſon why I have called ſome of them common to both organs, and others proper to one or the other. As to the penis *a*, it is nervous and of a muſcular texture, conſiſting, as it were, of three parts; the firſt is a muſcular membrane, then the inward conſtruction, wherein, as in a prepuce, the penis may move up and down; and laſtly, the internal porous membranes, which truſs up the penis on the inſide. Hence it is, that if the penis be cut off in the act of coition, no more than the outward membrane which covered it, and out of which it ſtretched itſelf, remains in the body. It is all white, and is firm, and, as it moves up and down very eaſily on the inſide, ſo it as eaſily moves through the aperture of the genitals out of the body, and can enlarge and ſtiffen itſelf for that end. For this purpoſe it has not only a muſcular texture, but it is likewiſe provided with a peculiar muſcle *o*, by the ſtrength of which it is thruſt out.

The act of coition is performed in this manner; firſt, the outward aperture of the genitals opens itſelf in the right ſide of the neck, fig. XVII. *a*; which, when it has more and more inſenſibly dilated and expanded its orifice, then the two inward orifices, as well of the penis as uterus, fig. XVIII. *b*, creep out of the body. Then the penis erecting itſelf, fig. XIX. *c*, and puſhing ſoftly out of one of theſe orifices, comes in ſight; but the other aperture, that of the uterus, lies open *d*, to receive the penis of the other Snail at the time of coition. So that the penis *e* of the one Snail is put into the aperture of the neck of the uterus *f* of the other; and again, the penis of the latter *h* is likewiſe received by the aperture of the uterus *g* of the former. Each of theſe Snails being therefore excited by a reciprocal ſtimulating impetus to venery, each impregnates and conceives, fertilizes and is fertilized, and ejects and receives the ſemen.

After coition all theſe parts are drawn into the body; for which purpoſe the penis has a ſomewhat long and even muſcle, Tab. V. fig. x. *p*, which is inſerted under the tranſverſal or oblique muſcle of the abdomen, where the verge of the Snail's body is: and that this part ſhould not want ſenſe, it has likewiſe a nerve *q*.

The parts of the uterus have alſo their nerves and muſcles, ſome of which may be ſeen in the neck, near the root of the four horns. The matrix itſelf is a tender, oblong, white and curled *ccc* little tube, which appears moſt remarkable when it is diſtended, fig. XVI. *r*, with air or wind; for then it turns itſelf into very admirable convolutions, being jointed to a ligament, fig. x. *nnn*, which connects all its folds, and is of a ſtronger ſtructure than the membranous and hollow parts of the tube of the uterus. This ſeems deſigned for ſome particular uſe; for it appears full of glands, ſo that I firſt took it for the ovary itſelf: for indeed all the veins of the uterus, of which there are many, are faſtened in this ligament, and paſs through it towards the uterus. But, in other reſpects, neither the uterus nor ovary, fig. x. *dd*, have any thing remarkable in them, as long as the former has no eggs in it. The ovary is not viſible, unleſs it appears like an oblong, white, tender, ſoft and triangular little part, and contains a ſubſtance like the melt of Perch. So ſmall and inviſible are the little eggs of the Snail before coition!

Again, the uterus is faſtened near the verge of the Snail, and is there connected with the upper part of the abdomen. There are likewiſe ſome muſcles which ſerve to contract the uterus, a larger one *s*, and a ſmaller *t*, which is inſerted behind the long muſcle *p* of the penis. The uterus has alſo its nerve *v* there; as will appear more clearly in the deſcription of the brain; where it will likewiſe be ſhewn that theſe muſcles alſo give ſome aſſiſtance to move the brain on the inner part.

That the penis and uterus in the Snail have many parts in common between them, I am inclined to aſſert, for this reaſon; becauſe theſe parts are forced to move their contents through common paſſages, as is ſeen in the ſperm from the teſticles, and on other occaſions. Theſe teſticles *e*, as we have before obſerved, conſiſt of a cluſter or heap of oblong filaments; and the ſame holds in almoſt all ſpecies of this genus of inſects: it is even ſo univerſal, that it takes place in man and quadrupeds; for their teſticles are formed of ſuch filaments. There are ſixty-ſix of theſe threads in the Snail: they are of a whitiſh colour, and, in their inward ſtructure, reſemble hollow tubes, each being cloſed up at its extremity. They ariſe from two trunks, and are divided in a wonderful manner, as it were, into twigs, Tab. V. fig. XI. *x*. The ſemen is of a ſnowy colour, and of the ſame thickneſs and clamminеſs as in the males of Bees. I know nothing that bears a greater reſemblance to this part, than the pancreas of fiſh; a deſcription of which I have inſerted in a work of Commelinus, which I publiſhed; and I have delineated the figures with my own hands.

The hidden appendage, fig. x. *f*, of the uterus is a very beautiful, white, nervous and muſcular part, of a firmer ſubſtance and texture. If it be diſſected, it muſt be done very cautiouſly and with an even hand: it is then diſcovered, that at the root or baſis in the hinder part, it has, fig. XII. *y*, a globular and round little part in the form of a pear; from which ariſes a ſharp, hard and crooked ſtyle, not unlike a ſharp awl. This little bone being taken out and viewed with a microſcope, reſembles a tranſparent, glittering, very ſmall, ſcale of a fiſh deprived of its ſkin. At the root, fig. XIII. *a*, on the hinder part, where this little bone is connected to the globular little part, it exhibits ſome inciſions or fiſſures covered with coats, which penetrate inwardly from the external parts into its cavity. I have counted fourteen of theſe inciſions: it appears, in general, equal and round *b*, and ends ſomewhat ſharp like a needle: then it forms, in its circumference, four margents or prominent borders *c*, between which are ſeen ſome remarkable ridges and furrows. This appears very plain when this minute part is diſſected, fig. XIV. *e*; for then it is manifeſt that it is hollow on the inſide; ſo that a hair put into it, almoſt entirely paſſes through it. Within the cavity of this little bone, there is contained a limpid or clear humour; but where its root is connected with the globular part, fig. XIII. *b*, it is all hollow and very tender, ſo that it is eaſily broke in that part, if it be handled in the leaſt roughly or careleſsly. It ferments ſtrongly with aqua fortis: hence I call it an alcaline little bone.

I could not find out the uſe of this little part. I thought indeed at firſt that it was the penis, but experience convinced me of the contrary. It is however certain, that it is of ſome uſe in generation; for after coition, ſuch little parts are commonly found where the Snails have been together. I have obſerved alſo the ſame thing in other kinds of Snails, till at length I made uſe of it as a ſign to diſcover whether the buſineſs of generation had been over. In ſome Snails which were not given to venery, I found this little part ſo ſmall, that it was hardly one fourth ſo big as that already deſcribed: it was like a point, ſlender, ſhort, and tender. In ſome it was larger, in others ſmaller, that is, as far as I could judge, the nearer they approached to the time of generation, or the further they were from it. It is ſometimes partly yellow, but for the moſt part it is tranſparent and very white; it ſeems, however, to be ſubject to accretion, like corals, as I ſhall demonſtrate more clearly in the Snail-ſtone. I remember to have ſometimes ſeen in a Cuttle-fiſh, an entire little bag full of ſuch white ſmall parts, which lay there free and diſengaged among a glutinous humor, but they conſiſted of a very ſoft ſubſtance, and were much larger. This fiſh has gills likewiſe, and other ſuch wonderful parts; ſo that this animal deſerves very particular conſideration, though much could not be hitherto known or ſaid concerning it.

The common little tube that lies between the penis and uterus, Tab. V. fig. x. *g*, is not very remarkable; I only obſerved that it was hollow. But that other, vas deferens *hh*, ſeems to ſupply more ample matter for ſpeculation, both becauſe it opens into the uterus *i*, and that it has a little ball or globe *k* in the form of a pear, which contains a fluid of a pale purple colour, ſomewhat glutinous, and not thin. This little ball lies next to the heart in the body; ſo that the great artery is carried round that pipe with which the ball is connected; but what uſe this little part is of, I could never hitherto diſcover. I once obſerved, that the little bone before-mentioned, penetrated into this veſſel, almoſt as far as its aperture into the uterus; but, to the beſt of my remembrance, I had then irritated the Snail at the time of coition, ſo that it drew in theſe parts of generation; for which reaſon I afterwards uſed to diſtinguiſh, in a particular manner, thoſe Snails which had exerciſed coition. Of what uſe this little globe or ball is, I am ignorant; I ſhould, however, be inclined to believe, that this is the part wherein the Purple-fiſh carries that precious dye, wherewith the garments of monarchs, and other great perſons, were coloured purple in the times of the Romans. To this the ſacred writings allude, when they ſay, "that the rich man was cloathed in purple."

I am likewiſe at a loſs to know of what uſe the curled little veſſel *l* is. I obſerved, however, that it is diſtributed into various little branches *z*, which, like ſo many tubes, ariſe from the oblong, round, and acute little part, placed near the extremity of the ſpiral liver, and there joined to the liver itſelf. But if this little part be divided, and opened or unfolded, with the top of an ivory bodkin filed ſharp, and ſomewhat ſoftened by ſteeping it in water, by which means it does not offer ſo much violence to the parts as a needle, it appears like a little tree or ſhrub adorned with leaves, Tab. V. fig. xv. *a*; with this difference only, that its extreme parts are ſtudded, or emboſſed and ſwollen, hollow on the inſide, and full of moiſture, which is probably conveyed by degrees into that curled ſmall veſſel reſembling a chain; but then the matter contained in this little part is more white and compact, and better digeſted.

Laſtly, we muſt obſerve that moſt of the parts hitherto enumerated, are placed behind in the ſpire of the ſhell, and are there ſeen through it in ſeveral places.

CHAP. IX.

Of the manner in which Snails mutually perform the buſineſs of coition.

HAVING hitherto, in part, ſhewn the method whereby Snails generate, I ſhall now give you a full deſcription thereof; ſince it is a matter very worthy of notice that, an hermaphrodite little creature ſhould have need of a companion for the purpoſe of generation.

The Snails gather together for ſome days before their coition, and lye quiet near each other, eating very little in the mean time; but they ſettle their bodies in ſuch a poſture, that the neck and head are placed upright. Thus, whilſt the ſhell of each reſts upon the earth, with its double head, the Snails are raiſed upwards, and they ſupport themſelves erect, by the extreme ends of the fringes and verge of their bodies, in the ſame manner as it is ſaid Serpents engender, that is, in an erect ſituation, and twiſted about each other.

At that time the verge, or its aperture, is continually open to take in the air; but the opening of the genitals in the neck is ſometimes obſerved to be alternately open and contracted. This action is performed in the ſame manner as the agitation of the outer parts of the vulva in Dogs and Hens, when they deſire coition. The Snails being thus animated, ſoftly approach each other, and apply their bodies one to the other, as ſmoothly as the palms and fingers of both hands can be graſped together: and by this means, not only their bodies, but their necks and heads, are raiſed up and preſſed cloſe to each other. Then are ſeen the moſt wonderful motions of their heads and eight horns, which ſurpaſs all imagination; like Turtles, they are continually obſerved to kiſs each other, and to join lip to lip. The horns are affected with ſuch various motions, that one can ſcarce think, how they can poſſibly have ſo many and ſuch different muſcles. Another circumſtance that deſerves notice is, that when they touch each other in the leaſt with their horns, they immediately draw them in, or move them up or down again, or ſideways; and theſe motions are often repeated.

Theſe motions ſometimes continue for three days, during which time the Snails turn in and out, and join together their genitals, ſo that the penis and uterus, of each, are ſometimes ſeen to hang entirely out of the body. But ſince I cannot obſerve that Snails have organs proper for ſeeing and diſcovering things near and at hand, but only for remote objects; hence it is, that for want of this knowledge, I cannot obſerve their coition but by chance. For though they very often ſhoot their genitals, like an arrow out of a bow, yet the coition is ſcarce performed once in three times. This miſtake ſeems to happen the oftener, becauſe every Snail carries its penis in the right ſide of its neck: it muſt therefore happen before they have turned their reſpective heads croſs-wiſe towards each other, that they often attempt a coition unſucceſsfully. But they have leiſure enough to repeat this buſineſs, ſince they feel for a long time the incentives of their venery, though they have already gone through the buſineſs of coition ten or twelve times before. Nay, I have known ſome of them indulge their venereal deſires three weeks afterwards, and that they repeated them again in ſix weeks after that.

But when they aſſociate in coition, as they ſhould do, each of them ſtretches its penis, together with the orifice of the uterus, entirely out of the body, which is not done by erection only, as it is in quadrupedes, but principally by turning the inward parts out, as happens in the penis of Drakes. The firſt thing that opens in the Snail is the aperture, that lies in the neck between the upper and lower horns, Tab. V. fig. XVII. *a*; then the inward parts of generation are obſerved to come out like two apertures, fig. XVIII. *b*; ſo that by this means the lower horn is puſhed out of its place, Tab. V. fig. XVIII. *k*: afterwards theſe parts are very ſuddenly thrown out of the body; yet ſo as that the aperture of the uterus appears firſt, fig. XIX. *d*, and immediately after the penis, the thicker part of which turns out firſt, and afterwards the ſharp part *c*. After this begins the coition, and the two lower horns are then ſo far thruſt out of their places, that they touch and preſs each other *l*. Theſe parts are afterwards remarkably ſwelled by the humours that flow towards them, ſo that they reſemble the clammy white of the boiled egg of a Lapwing, which, being mixed as it were with a tranſparent whiteneſs, makes a very agreeable ſight, reſembling an agat. For the appendage of the penis, fig. X. *bb*, is obſerved to run ſo far, and by the clearneſs of thoſe parts, is ſo evidently ſeen, that its motion is alſo obvious to the eye.

After coition the parts before-mentioned may be ſtill perceived for a quarter of an hour hanging out of the body, that is until their ſwelling has fallen, and then it is ſurpriſing to ſee what wonderful motions the penis has. But if any one ſhould in the mean time handle theſe parts, the Snail endeavours to draw them in by force, but however much it ſtretches all its nerves, yet it cannot by any force bring them in, unleſs they firſt become flaccid. A certain lympid moiſture then diſtils from theſe parts, which ſoon coagulates, and becomes tenacious and firm in the air. The upper horns being always bent like a circle in the venereal act, are obſerved not to move much, unleſs that they are ſometimes drawn in, and again ſtretched out. After all is finiſhed, the little creature, having wantonly conſumed the ſtrength of life, becomes dull and heavy; and thence calmly retiring into its ſhell, reſts quietly without much creeping, until the furious luſt of generation gathers new ſtrength, and effaces the memory of the uneaſineſs ſuffered after the former coition.

In a Snail, diſſected a little time after the act of generation, I obſerved that the penis was ſmaller, but the uterus a little more expanded and glutinous in its cavity. The ovary was manifeſtly ſwelled, and was longer, thicker, and larger, ſo that it now ſeemed full of ſperm like milk. Afterwards, however, I ſaw it much larger, and filled with more glutinous moiſture. But in five weeks after coition, the ovary became yellow, and like real glue; yet the eggs were very ſoft like ſlime, and were ſcarce viſible. When I afterwards viewed the ovary in ſuch a boiled Snail, every thing was callous, and as far as I could diſcern, an infinite number of little eggs preſented themſelves in both the Snails, which had copulated with each other. The uterus itſelf was likewiſe at that time much more expanded, and became, as it were, glandulous; ſo that when thrown into the water, it ſwelled very much. When the eggs were held a little while in the hand, the fingers ſtuck together. Therefore the ovary, the longer it paſſed after the time of coition, became more tenacious, compact and yellow; for all the eggs of the Snails are covered with very clammy membranes, and are, at length, perfected in the uterus. They cannot remain in the ovary, ſince this is placed between the ſpiral part of the ſhell, and throws its eggs into the cavity of the uterus. Some Snails lay their eggs up and down on the ground, others tie them all together like a chain. I have ſeen a little chain of eggs of this kind, which the vulgar thought dropped down from heaven, and therefore immediately framed a great many ſuperſtitious fables concerning it: ſo far is ignorance the mother of error. The teſticles, after coition, are found deprived of their ſperm. The blind appendage of the uterus likewiſe, in the beginning, though not very much, became afterwards contracted, and had thrown off its bone. The common tube between the penis and uterus ſuffered no change. The vas deferens was more dilated, and in it, as I have ſaid, I found the little bone. Hence it is probable, that this little bone, at the time of coition, carries ſome of the ſpermatic humour through the upper tube of the vas deferens into the uterus; whilſt the penis, in the mean time, throws its ſperm from the inward part into it. To conclude, the little part in the form of a chain had undergone no change, unleſs that on the ſide near the ſpiral convolution of the liver, the veſſels that it diſtributed there, were here and there very unequally dilated and filled with a calcarious humour; except that ſome little round whitiſh membranes, which appear perforated in the middle, and marked with a black ſpot, were here and there obſerved fluctuating in its hollow canals, which reſemble the leaves of trees.

CHAP. X.

Of the brain and nerves, and in what manner thoſe parts have their muſcles, whereby they are moved backward and forward in the body; a wonderful particular not hitherto known in any animal.

IT is with very great difficulty that any certain and fixed place can be aſſigned to the brain of the Snail, as I have obſerved in the beginning of this account; ſince, like other parts, it has its muſcles, whereby it is ſometimes drawn forward, and ſometimes backward in the body. This motion of the brain is ſo wonderful in this little creature, that it deſerves the moſt ſerious conſideration. Since I have never hitherto, nor do I know, that any other has, obſerved any thing like it in any kind of animal; I ſhall, for that reaſon, minutely deſcribe the brain, and repreſent it by a figure, as I have ſeen it in a Snail, which I killed ſlowly under water. The brain is placed upon the ſtomach itſelf, which, together with its gullet, always paſſes through the aperture which the brain forms there. And this is not peculiar to Snails only, it holds likewiſe in Silkworms, and in all other inſects that I have hitherto examined. Hence it is, that when the ſtomach, with the gullet, and all parts of the mouth, are drawn up on the outſide, or down on the inſide; the brain being always placed upon the ſtomach, is transferred hither and thither with it. Since therefore all parts of the mouth may be, according to the diſſection of the brain before-mentioned, drawn forward and puſhed out; I ſhall, in the firſt place, expoſe to view all the parts of the jaws, mouth, and palate, Tab. VI. fig. 1. *a*. Leſt the ſtomach and its oeſophagus ſhould interfere in my giving a full and exact repreſentation of the brain and nerves, as they really are, I cut the ſtomach about the gullet *b*, by which means the brain is ſeen immediately. It conſiſts of two parts like little globes, and is therefore divided into two parts: from each of theſe globes ariſe a certain part of the ſpinal marrow, reſembling on each ſide a large nerve *dd*, both which parts are ſituated in ſuch a manner as to leave a gap or aperture for the paſſage of the ſtomach. Theſe parts, ſpringing from the brain, conſtitute the true principle or rudiments of the ſpinal marrow, and they meet again a little lower, and form a conſiderable knot, Tab. VI. fig. 1. *e*; from which, afterwards, ariſe all the reſt of the nerves that are diſtributed in the lower part of the body. There we are to obſerve, that the ſpinal marrow is double, not only in this creature, but alſo in man himſelf, and in quadrupedes; with this difference only, that in the latter it is preſently joined together by a certain intervening band, and immediately after incloſed in a common membrane. Nay, all the nerves in the latter, that ariſe from the marrow, form, each in its courſe, certain little knots or ſwellings, which are therefore at leaſt more numerous there. The ſame is ſeen in Silkworms, in which the two originations of the ſpinal marrow are many times tied.

This ſwelling of the ſpinal marrow in the Snail has its muſcles likewiſe, by the help of which it is moved up and down in the body. Its firſt muſcle is very ſmall *f*, ariſing from a coat which covers the ſwelling or production: from thence, paſſing under the ſtomach and brain, is at length inſerted by its tendon, in the lower region of the parts of the mouth, a little above the root of the tongue; therefore it can move this little knot and the brain towards the fore parts. The reſt of its muſcles, which draw it back again to the hinder parts, are common to the inward lips; for the muſcles of the latter run on each ſide over this ſwelling, and fix ſome of their tendons therein, though they are otherwiſe inſerted in the horny ſubſtance of the Snail. After theſe muſcles have paſſed over the ſwelling or production of the ſpinal marrow, they acquire a little nerve from that part which gives them the power of contraction. To avoid confuſion, I have here exhibited only a ſmall part *g* of theſe muſcles, with their little nerve, which is afterwards extended further from thence towards the ſpiral turnings of the Snail's body, being there probably of uſe to provide for ſeveral other parts.

We further obſerve two nerves *hh* ariſing from the brain, which are diſtributed into the ſeveral parts of the jaws, mouth and palate, and probably ſerve for divers uſes. But the optic nerves *ii* which have the eyes placed in their extremities, ſwelled out in form of little globes, are extremely beautiful. Behind theſe are diſcovered two other nerves *kk*, which reach, each with three ramifications, to the fore parts of the skin, and to the baſes or roots of the upper horns; and afterwards alſo give two little nerves *ll* to the lower horns, which are of the ſame ſtructure with the nerves of the upper, and are alike terminated with globular ends. Beyond theſe a pair of very tender nerves, Tab. VI. fig. I. *mm*, ſpring from the brain, each of which being divided into two branches, runs to the muſcles of the ſkin of the head, and is inſerted in each ſide of the Snail's lower horns. Laſtly, two larger nerves *nn*, are diſcovered, which run under the parts of the mouth, jaws and palate, and diſtribute themſelves over thoſe parts, and are deſigned probably for motion or taſting, or for both.

Again, ſome of the nerves which ſpring from the ſwelling or production of the ſpinal marrow, are inſerted in muſcles, ſituated in each ſide of the neck *oo*, to which they give motion. Others, on the contrary, are ſent away to the ſpermatic veſſels *p*, and to the coat and muſcles *q*, which cover and move them. Some nerves alſo iſſue *rr* from thoſe ſwellings, which are diſtributed in the muſcular parts that move the ſides of the body. Above, on the right ſide of this little knot, there ariſes an oblong little nerve, which is defended by a like muſcle, and reaches to the uterus *s*. This muſcle may probably alſo ſerve to move the ſpinal nerves on the inſide. Behind the former are two other oblong nerves, one of which bends back under the little nerve of the uterus; but the other, being again divided into two branches, is inſerted in the verge of the body *t*; at the upper part of which are ſtill ſeen ſome muſcular fibres, which iſſue from the tranſverſal muſcle of the abdomen, which is ſituated within, under the arch of the membrane of the verge. On the other, or left ſide, a like nerve is obſerved alſo *v*, which has the ſame inſertion, and ſerves for the ſame uſe, that is, to to give ſenſe and motion to thoſe parts. In the left ſide we are likewiſe to obſerve, what manifold and ſtrong nerves are tranſmitted to all the middle and lower parts of the body. We will firſt examine thoſe in the middle. Some nerves are there inſerted, Tab. VI. fig. I. *x*, between the tendons fig. II. *nn* of that ſtrong muſcle, which moves the middle of the body, and thoſe are ſent away to the ſeveral muſcles that run near it. A conſiderable number of little nerves beſides *yyy* are obſerved, ſome of which are long, others ſhorter, and ſome are divided into two, others into three lateral branches: theſe deſcend to the lower verge or foot of the body, in order to give it the power of feeling and moving. I have exhibited none of theſe nerves in the right ſide, to prevent confuſion *z*.

Here we ſhall conclude the preſent chapter. Now, reader, judge whether God has not ſhewn himſelf as magnificent and aſtoniſhing in the the texture of the brain and nerves of the Snail, as in the formation of the ſimilar parts of man; excepting only the mind and principle or ſeat of the underſtunding. As thoſe do not appear to the diſſecting knife, ſo they are leſs proper to come into our analogy or compariſon; for thoſe only obſerve and inveſtigate corporeal and ſpiritual things, and thence deſcend to the deepeſt abyſs of the wiſdom and ſecrets of God.

CHAP. XI.

Of the muſcles of the body and ſhell, which is the bones of the Snails: in what a wonderful manner this ſhell is formed on the inſide, and how it is increaſed and nouriſhed. Laſtly, how the Snail moves in its egg.

THOSE who have ſeen diſſections, or have any knowledge of anatomy, know, that the hiſtory of the muſcles cannot be accurately underſtood, before the bones in which they are inſerted are firſt known. For the latter are fixed points, towards which every thing in the body, that has a ſtrong motion, is drawn and moved. And though the naked Snails have properly no bones, yet they have a certain extremity, wherein muſcles are inſerted; as I ſhall ſhew in its proper place.

That wiſe architect, who alone framed and reduced all things into order, has likewiſe eſtabliſhed different rules in the compoſition of animals, by the aſſiſtance of which he has purſued the ſame ends and purpoſes, how greatly ſoever the ways and means to arrive at thoſe ends differ in various inſtances. In ſome animals the bones are found placed in the body, with fleſh ſpread about and affixed to them, as in a man, quadrupedes, and in ſome birds. In others, we can only find cartilages, wherein muſcles are inſerted, as in the Ray-fiſh and ſome others. The Cuttle-fiſh has only one bone in its body, except the noſe or ſnout. In ſome, which are ſo ſmall that they have no conſiderable bones, the muſcles are inſerted in the skin itſelf, or they meet together in certain callous or firm points, which are formed for that purpoſe, and which, in particular places, are as hard as the ſofter part of a Cow's horn. Though the methods hitherto mentioned, tending to one and the ſame end, differ greatly among themſelves, the wiſe Creator of the univerſe has, beſides, invented many others much more wonderful: in ſome animals he has formed bones manifeſtly on the ſurface, and put fleſh between them with the moſt exquiſite art, as in the Cray-fiſh, Crab, and many others; and he has likewiſe followed the ſame rule in moſt kinds of Inſects, and likewiſe in this kind of Snails, to which the ſhell is as a real bone. The immenſe power and wiſdom of God ſhew themſelves greateſt and moſt profound in thoſe little animals, to which he has given both an horny ſhell, and the harder coat of a Crab; ſo that the muſcles of the ſofter part are inſerted in the ſhelly ſubſtance of their bodies, whilſt that very judicious architect has inſerted the reſt of them in a hard bone, which covers their body, and is continued therewith out of the ſhell, as may be obſerved in the Hermit-fiſh. Though the Tortoiſe lives in a little houſe as it were, and carries its bones, like the ſhell-fiſh, on the outſide, yet God has again eſtabliſhed a different order in that creature, ſince he has given it two ſorts of bones, ſome which grow contiguous with the bone that covers it, and others which are fixed to it by the help of joints; ſo that by this means the muſcles are in this creature ſtrengthened with a double inſertion. And as this exhibits a very uncommon object in a living Tortoiſe, ſo the ſutures of the bones, which conſtitute the outward ſhell, are worthy of particular obſervation; for, in my opinion, they differ from the ſutures of the bones of all other creatures whatſoever, as I can demonſtrate by a ſhell that I keep in my collection. But ſince this animal alſo lays eggs, that are covered with ſhells, which I have ſeen in great numbers in the body; and ſince thoſe eggs muſt be emitted through a very ſmall aperture in the bone, on one ſide of the tail, through which they can by no means naturally paſs, it is beyond all manner of doubt, that the ſutures of the bones in this creature, muſt, at the time of the excluſion of the eggs, ſeparate from each other. Anatomiſts, with all their force, oppoſe the notion of ſuch a thing happening in human ſubjects at the time of delivery. I ſhall not pronounce, for certain, how this matter is, but I believe moſt firmly, that ſuch a temporary ſeparation happens in Tortoiſes.

To return to the bones and muſcles; we muſt obſerve, that the muſcles are not ſimply inſerted in the bone, but that a certain part of the bones themſelves conſtitutes one of the extreme ends of the tendons of the muſcle, ſo that the muſcles fixed in each ſide in the bones have two bony extremities. Every muſcle therefore conſiſts of three parts; the middle part is fleſh, but the two extremities are the white, membraneous, firm, and fibrous joints of this fleſh, which become bony where they are inſerted in the bone; or otherwiſe remain hard and compact, or become ſofter and more tough, according to the different nature of the parts to which they are joined, and which they are conſtituted to move. Hence it happens that a muſcle is ſometimes inſerted in a muſcle. Nay, which is ſurpriſingly ſingular and uncommon, Mr. Stenon has demonſtrated to me, and to my very eſteemed friend Dr. John Oort, in the eyes of birds, after what manner a muſcle paſſes through a muſcle by its tendon, as through a pully, ſo that the perforated muſcle can draw to itſelf, or let looſe the perforator, according as the tendon of the latter, paſſing through the former, ſhould be brought nearer or removed further; than which ſtructure ſcarce any thing appears more admirable.

After what manner the muſcles are inſerted in the ſhell or bone of the Snail, and united therewith, appears moſt manifeſtly when that houſe of the creature is opened, for it is then obſerved, that all the principal tendons of the muſcles of its body, run, ſome a little lower, others ſomewhat higher and deeper, towards the ſpiral part of the ſhell, and are fixed, Tab. VI. fig. II. *a*, in the ſhell itſelf, or hard or ſtony bone of the Snail. This may be ſeen particularly in that winding or ſinus of the ſhell, which is the ſecond from its lower aperture; I mean that through which the Snail throws out its body and verge or foot. There may, after this, be further obſerved, the inſertion of the two longeſt muſcles *bb* of the Snail, which ſerve principally to move that great and ſmooth verge or border of the body, by the aſſiſtance of which, as with a broad kind of foot, the Snail creeps forward, and moves from place to place; but this muſt be done with a very ſlow pace, according to the proverb, "Slower than a Snail." Thoſe muſcles in the middle of the body, where they are for the moſt part inſerted, form a ſtrong tendon; between which, towards the hinder parts, is ſeen here and there ſome moiſture, which is yellowiſh, pretty thick, and contained in peculiar little cells, of the uſe whereof I am hitherto entirely ignorant. Backward, under the extreme part of the ſhell, we ſee the fibres of theſe muſcles *c* run, which are inſerted in the tail of the creature, or loweſt extremity of the fringe, which is moved by them. Moreover, there is ſeen the parts, Tab. VI. fig. II. *d*, wherein all the tendons of the muſcles of the verge, that ſurrounds the upper part of the Snail's body, have their origination. And thoſe, together with the tendinous ſkin that covers the whole ſpiral part of the body, afterwards aſcend to the laſt or extreme point of the ſhell, but are no where further inſerted; they are only curled, and there they contract the extreme end of the liver, and move it occaſionally, together with the inteſtines. Above, and near the inſertion of theſe, is ſeen a ſmall muſcle *e*, which draws in the parts of the jaws and mouth, and the cartilage, with which the tongue is covered, together with the palate, and ſome other parts annexed. I deſcribe and repreſent this in ſuch a manner, that the baſis of the tongue *g*, and its fore-pointed extremity *f*, which is armed with a kind of horney teeth, may be clearly diſtinguiſhed; although they are all neceſſarily put ſomewhat out of their natural ſituation. Afterwards appear thoſe two admirable muſcles *hh*, which, by turning in the two upper horns through their cavity, draw the eyes back into the body; the curled foldings *ii* of the optic nerves are found to be tranſparent through thoſe muſcles, and are ſeen to run towards the eyes. The eyes themſelves ſeem like two black points *kk*, over which a certain part of the horns thus drawn in ſtill appears: under the former, are ſeen two plain, equal, or ſmooth muſcles *ll*, which draw the lips and ſome other parts of the mouth into the cavity of the body; at the ſides of theſe appear a pair of muſcles *mm*, which are inſerted in thoſe of the lips before-mentioned, and ſerve to draw back the two lower horns into the cavity of the Snail's neck. Between the muſcles hitherto deſcribed, are found two very wonderful and ſtrong muſcles *nn*, which are inſerted with two firm and tough tendons in the middle of the body; this is variouſly and ſtrongly moved by them, and is raiſed or elevated into the orifice of the ſhell by their power; between the tendons of thoſe muſcles is the proper place of the ſpinal marrow in the Snail, which from thence diſtributes its nerves to all the adjacent parts; the latter ſupplying the nervous fluid or moiſture, and giving the power of moving and contracting; as may be ſeen very diſtinctly in the body itſelf. But after what manner the bone of the little habitation or ſhell of the Snail is formed, and what windings, partitions, cells, diviſions, and cavities it has; this truly ſingular piece of art may be traced very eaſily in a natural ſhell, as I have endeavoured to expreſs its ſtructure, according to nature, with all the accuracy of which I was capable. Laſtly, the extreme edge of the fringe or foot of the Snail, Tab. IV. fig. II. *qqqqq*, in which I have delineated all the muſcles hitherto mentioned, deſerves to be carefully regarded. The fleſh, and the fibres and tendons are of a ſpotleſs white, ſo that there is not much difference in this reſpect between the fleſhy and the tendinous part, unleſs for the ſmallneſs and ſolidity of the fibres.

Thoſe parts being, in the firſt place, thus explained and underſtood, I ſhall proceed to deſcribe and to expoſe to ſight the inward parts of the ſhell. The firſt part which deſerves conſideration, is the outward orifice of the ſhell, fig. III. *a*; which being by little and little contracted and twined round, forms its ſecond diviſion *b*, and thence afterwards aſcending further, it forms a third *c*, and at length a fourth *d*, and a fifth *e*, which is the laſt, and has the extreme end of the liver placed in its cavity.

If any one diſſects the ſhell with a fine ſaw, made of a ſmall piece of a watch ſpring, and afterwards breaks open all the inward cells and diviſions with a ſharp pointed forceps, he will ſee very beautifully how this turning about or winding on the inſide is effected; and how the five ſeparate lodgements in the ſhell are compoſed and twiſted in a ſpiral form, as I have repreſented from the life, in Tab. VI. fig. IV. numbers 1, 2, 3, 4, and 5.

The ſhell of the Snail makes as beautiful a figure, if it be prepared in the following manner; it is to be cut ſo that the inward poſt, or the columella or pillar, about which all the cells and inward diviſions are turned, remains alone; in this caſe, in the upper end of the pillar, where the fifth and laſt lodgement is opened, there is ſeen a ſmall aperture, fig. V. *a*, which paſſes *b* through the whole pillar, from top to bottom, and is always larger and wider at the entrance of the ſhell, than where the decreaſing windings are terminated. Theſe apertures are ſeen yet plainer, if the loweſt part of the pillar be taken off, fig. VI. *c*, and the pillar itſelf conſidered apart. In many kinds of theſe bony habitations, theſe apertures of the pillar are very plain, from this cauſe, that all the windings of the ſhell have each their particular and diſtinct diviſions, which are faſtened and joined together in their twiſtings: we are to except from this account, ſuch ſhells as have no winding, and are therefore called tubules or tubular ſhells.

For theſe reaſons, therefore, this kind of ſhelly covering muſt be conceived as a certain oblong, hollow, ſharp, and flexible tube, which if rolled and turned round a ſmall iron line or wire, and afterwards this thread or line were drawn away from it, would ſhew ſuch a perforated pillar, which would be the more exact, if all thoſe foldings, together with their incloſures, were applied cloſely to each other, and faſtened and united together. And after this manner are almoſt all kinds of ſuch little ſhelly habitations built, in whatever wonderful manner they appear to be turned or conſtructed. This I myſelf have found, by ſtrictly examining many different kinds of them which are in my father's muſæum. This appears however much clearer in ſome ſpecies than in others, in thoſe ſhells, particularly, which are called tubules, and which are twiſted, Tab. VII. fig. V. *b*, only at their extremity. This conſtruction is ſo plain as to be beyond all manner of doubt. I ſhall therefore hereafter exhibit other kinds of ſhells in their proper places, that the difference may be known as far as poſſible, and by the feweſt examples.

From each of theſe larger habitations may be formed as many ſmaller as can be deſired, provided we firſt break off the pillar and the internal ridges, and afterwards make them even and ſmooth with a file. This is indeed contrary to the order of nature, for ſhe always proceeds from the leſs, Tab. VI. fig. VII. *d*, to the greater *e*, and ſo on to the greateſt *f*. I have prepared by art in this manner the diſtinct little ſhells which I here exhibit as gradually augmented. And that the method whereby this increaſe is performed by nature may be conceived, I ſhall now deſcribe and explain how this habitation of the Snail is increaſed and augmented.

In this ſpecies of Snails, I could never diſcover the rudiment of the ſhell in the egg itſelf; but by obſerving other kinds I have found that the little egg laid by them produced always a very ſmall but perfect Snail; and any perſon may know, from reaſon, that it muſt happen thus, ſince the Snail's muſcles would not be otherwiſe ſtrengthened by any inſertion, which no body in his ſenſes would even have thought; but I follow experience, as the only guide in this caſe. In other Snails I have often, through the outward ſhell, ſeen the little Snail lying in the egg, and moving very diſtinctly, before it came out, which I have been ſo happy as to ſhew to the illuſtrious Van Beuningen, our ambaſſador and conſul. One remarkable thing is, that as ſoon as the Snail is come out of the egg, it is perceived to be ſo large, that it ſeems wonderful how it could lie and move, ſo preſſed and wrapped up, in that elliptic and narrow cavity of the egg-ſhell.

Again, ſince the water Snails themſelves likewiſe move in the egg for ſome days before they come out of it, hence one is inclined to conjecture, that the young Snail does not leave the ſhell of its egg before it has arrived at a certain degree of growth; at which, having its little ſhell ſufficiently hardened, it is in a condition to creep out of the egg, and to increaſe its fleſh and bone, or hard covering, with the food it receives. This may likewiſe be ſeen in other animals, which bring with them into the world fleſh and bones out of the uterus, and only perfect them inſenſibly, by the uſe of their ſucceeding food. By this means, the Snail's ſhell is nouriſhed, as well as its ſofter parts; though the former is done in ſuch a manner, as to lead one to think that it is differs in ſome meaſure from the latter.

It is beſides this worthy of notice, that the ſhell of the Snail has its particular perioſteum, by which it is covered and incloſed. And the ſame may be obſerved outwardly about the horns of ſtags, for thoſe are likewiſe incloſed in a peculiar coat, which they rub off againſt the trees, and in proceſs of time wear away, that is, after the horns have acquired their full ſtiffneſs, and the skin that ſurrounds them is no more nouriſhed. I have found this membrane ſo ſtrong and tough in the ſhells of ſome Snails, that it would not yield to aqua fortis; but the ſhell itſelf, rather than the perioſteum, was corroded thereby. This membrane is likewiſe very conſiderable in the ſhells of ſea Muſcles, for to this the Muſcles faſten thoſe filaments by which they hang together, and fix themſelves ſo as to prevent their being carried away with the tide. The filament I ſpeak of iſſues from their body, and is very broad in the forepart, almoſt like a piece of a leather, wherewith ſome perſons draw on their ſhoes; and by the aſſiſtance of this, the Muſcles are not only joined to each other, but likewiſe cling firmly to rocks, wood, ſtones, ſea-weeds, or any thing that is near them. Thoſe filaments in other kinds of Muſcles, as in the Pianna Marina, are called Byſſus, and are that matter, of which, as of ſilk, that kind of very fine linnen uſed to be made, which, according to Rondeletius, was called Byſſus, and in which the rich man mentioned in ſcripture was clothed.

In the Snail whereof I here ſpeak, the membrane before-mentioned is pretty ſtrong, and it is viſible every where in all the notches of the ſhell, and their interſtices, Tab. IV. fig. II. *s*. In other ſhells of the ſame ſpecies, I have ſometimes found it worn out, by the creatures frequent creeping through ſtony places; but it is always conſpicuous near the aperture out of which the Snail creeps. If thoſe who delight in natural curioſities, or have muſæums, find a ſhell ſtripped of this inveſting membrane, they conclude that it was rolled in the ſea long after the death of the creature originally contained in it.

I have ſometimes obſerved that the Snail, being about to inlarge its habitation, firſt cleared away this perioſteum with its little teeth, nay, that it bit off ſome ſmall pieces therefrom, and ſwallowed them; however, I have obſerved alſo, at other times, that the Snail cleaned the edge or margin of its ſhell with its teeth, if it was covered with films, and that the Snail happened to reſt for any conſiderable time. I have likewiſe often found that the Snail, when it remains quiet for any time, forms films of that kind, and beſprinkles them with a calcarious matter, and then thoſe films will ferment with vinegar, as well as the ſhell itſelf, when worn or rubbed in the duſt. And indeed all theſe experiments evidently demonſtrate that this habitation is the real skin, or rather the hard or ſtony bone of the Snail, which covers it on the outſide.

But if this ſtony ſhell be accurately examined, it appears to conſiſt of numerous ſmall, tranſparent, and as it were membranaceous coats, which have inſenſibly petrified, or aſſumed the nature of ſtone; as may likewiſe be obſerved in Craw-fiſh immediately after they have caſt their ſhells, and in the bony ſkulls of men, which are at firſt only thin membranes, but are afterwards turned by degrees into bone. Theſe membranes are at firſt like water, and afterwards grow ſolid and increaſe, when many fibrous and angular particles grow by degrees under them, as may be ſeen moſt evidently in the heads of abortive children. The ſame things may be obſerved in the Snail's ſhell, if it be lightly calcined, and then put under the microſcope.

As to the method, whereby ſuch a ſhell is increaſed, the following are the chief particulars, the Snail's whole body is furniſhed with glands, from the orifices of which flows up a kind of mucus or thick matter, like ſmall and fine rays; which, like ſo many threads of ſilk or velvet, are joined together in one common cruſt or ſurface, and in proceſs of time are condenſed, and acquire the hardneſs which we obſerve in the ſhell. This mucus or thick humour then, is the firſt matter which grows into a membrane, and afterwards into a ſtony skin. Its filaments are very conſpicuous at the places where the windings of the ſhell are applied to each other.

The outward ſcale or enamel of the teeth, in men as well as in beaſts, likewiſe conſiſts of innumerable very ſmall and very fine filaments joined together, which I have found in ſome teeth hard and poliſhed, like real ſtone; though the teeth are at firſt but a kind of mucus or thick humour, and afterwards become membranous, and at length fully hard. I have ſeen the rudiments of teeth in abortions of five months old, which, together with their filaments, I now keep, and can ſhew in them this ſingular conſtruction.

My moſt reſpected friend, Mr. Stenon, has likewiſe diſcovered ſuch filaments in oyſter-ſhells, and made my father a preſent, for his muſeum, of a ſhell which was buried for a long ſeries of years under ground, in the mountains of Italy, and, by length of time and moiſture, inſenſibly had ſeparated, as it were, into many tender and ſmall ſhells: from this it is evident, that the ſhell itſelf was formed of thoſe, in its growth, in the manner I have explained. In corals I have found nearly the ſame method of accretion; that is, that they are firſt thin membranes, which, by an inſenſible increaſe of the little grains joined together, petrify; as may be ſeen in a work publiſhed by Mr. Boccone, of corals, in which are two letters of mine treating of the ſame matter.

If you likewiſe view the tendons of the Snail's muſcles, which are inſerted in this part of the ſhell, you will find that they have grown hard as a ſtone there; which is indeed eaſily known, both from the winding of the ſhell's pillar, which becomes larger by degrees, and from the inſertion of thoſe muſcles in the ſhell. In hens likewiſe, and in peacocks, the tendons of the muſcles are oſſified, or become by degrees hard as bones. Theſe tendons, eſpecially ſuch as are taken out of the lower parts of the foot, are made uſe of, by ſome with us, for toothpicks.

The opercula of the ſhells, Tab. IV. fig. III. *m*, have almoſt the ſame origin, though their ſubſtance approaches nearer to chalk or plaſter than to a ſtone; nor is it ſo hard, but is more ſpungy than the ſhell, and therefore is made thicker; but I have obſerved, that when the operculum or cover is finiſhed, and the creature enters deeper into the ſhell, it afterwards, under the membrane of the ſhell's operculum, produces, ſometimes two, ſometimes three membranes, of which ſome are thicker than others, and are more or leſs calcarious. About the center of this operculum, is likewiſe ſeen a membranous filament, which connects all thoſe membranes with the operculum, as if they were faſtened with a needle and thread. When the creature frames its operculum or cover, it retires by degrees more and more into the ſhell, ſo that the verge equally ſhuts up its whole cavity, and afterwards preſſes out the chalky moiſture, with the aſſiſtance probably of the ſacculus calcarius, or calcarious bag which we have deſcribed.

The principal part of the body that promotes the increaſe of the ſhell, is that verge of the Snail, which the creeping in of the Snail cauſes to ſwell ſo far beyond the extremity of its little habitation, as that creature wants to ſtretch and enlarge it, thus it preſſes by degrees a glutinous humour out of the glands of the body, and thereof immediately forms a membrane conſiſting of filaments, which it afterwards makes thicker and thicker, until it at length attains a due hardneſs and firmneſs, by the preſſure of the circumambient air. For this membrane is at firſt ſo weak and ſoft, that it breaks through on the ſlighteſt touch; and this is the reaſon why the habitations of Snails are found ſo often uneven with ſcars, and ſwellings on their ſurfaces.

If it ſhould happen that the ſhell be preſſed in by a fall, or by any other means, or be wounded or broken, theſe Snails know ſo well how to mend and conſolidate it by degrees, by the application of the petrifying humour, that it becomes more firm than it was before in the places which ſuffered the injury. The outward ſurface by this becomes very unequal and tuberous, but the inward ſmooth and poliſhed. Something like this is alſo obſerved in the fractured bones of animals, which nature can conſolidate again with a callous ſubſtance; but even thoſe are then alſo unequal on the ſurface after ſetting. We ſometimes meet with ribs of mutton in the ſame manner, which it is very certain have been formerly fractured. I have ſeen the ſame thing in different bones of men and other animals. I have ſometimes broke a Snail's ſhell ſo that I could put my little finger in the hole that I made, which, notwithſtanding, I have found filled up again in four days: ſo that the ſame means of accretion and tranſmutation, to all intents and purpoſes, are obſerved in the Snail's ſhell as in the bones of other animals, with this only difference, that the veſſels of the former are not conſpicuous; which may probably be owing to their ſmallneſs and delicacy, and becauſe the blood contained in them is white: but this makes no difference.

Another thing alſo very worthy of greater admiration is, that this ſhell will, even under water, whether it be freſh or ſalt, petrify or become hard as a ſtone, however much it has been like a fluid humour in the beginning. This

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may be ſeen in river and ſea Snails. But what ſeems to me a greater paradox is, that ſome inſects frame their ſhelly coverings, and weave their little nets under water, like Silk-worms, out of ſmall and glutinous filaments; ſo that theſe threads, which are ſpun from a fine and ſubtle humour, acquire their firmneſs, tenacity and hardneſs even in water, as well as the threads of Silk-worms do in the air. I can ſhew ſome very rare and uncommon experiments on this head in the water ſhell-fiſh which I preſerve. Let me add, that I have ſeen a Snail die the third day after I had taken it out of its ſhell; though in ſeparating it I had hurted none of the blood veſſels, and had likewiſe carefully left untouched that part of the ſhell wherein the muſcles were inſerted; but that Snail before its death preſſed out a certain membrane round the whole ſurface of its body. This membrane was the ſame in all reſpects as that on which I have made the preceeding experiments, and was intended by nature to ſupply a new ſhell. In the beginning the Snail was very ſprightly; but afterwards it inſenſibly languiſhed more and more, and at length, contracting itſelf under its verge, it died. Here end my obſervations on this ſpecies of Snails.

CHAP. XII.

Of the Hermit fiſh, and Pinna Marina. Of the inward turnings or convolutions of the turbinated ſhells. Of the Voluta or Cylinder, the Concha Veneris, and Pencil, and ſome other ſhells of the Snail kind.

IF all the things I have advanced in the preceding chapter be attentively weighed and conſidered, it will appear clear as the light at noon, that the Snail's ſhell is its real bone, without which it cannot live. Hence it appears what an idle fable that is which is eſtabliſhed even amongſt thoſe who ſtudy ſhell-fiſhes, when they ſhew ſome of the Crab kind in their muſeums, adding at the ſame time that they paſs from one ſhell to another, devour the animals that lived in thoſe ſhells, and keep them for their own habitations. They dignify them with ſounding names and additions, as Soldiers, Hermits, and the like; and thus, having no experience, they commit groſs errors, and deceive themſelves as well as others with their idle imaginations.

Some years ſince, when I was at the Hague, I employed ſome fiſhermen who lived at Scheveling, to bring me all the ſtrange fiſhes which they ſhould catch. It ſo happened that among the reſt they brought many ſmall Crabs, Tab. XI. fig. 1. *a*; each of which lived in a kind of twiſted, round, ſmooth and poliſhed ſhell; but when I viewed the animals themſelves more accurately, I obſerved that they reſembled Crabs only in their fore part, that is, they had four feet *gg*, and two forceps, of which the right *e* was much ſtronger and thicker, than the left *f*. I further ſaw there two tender feelers or horns *dd*, and two prominent eyes *c*; and under the latter there were placed ſome other ſmall parts. The inward part or body of this Crab was fixed to the pillar of the ſhell, by the tendons of its muſcles, but otherwiſe it was ſoft and conſolidated, as in Wilks and other Marina or ſea Snails.

Ariſtotle and Ælian tell us, that in ſome ſhells there are both a Crab and Snail together; hence the Crab has got the name of Pinnophylax or ſhell-keeper. Theſe authors likewiſe harbour another ingenious opinion, which is, that the Crab provides food for its companion the Snail; ſo that theſe two little animals live it ſeems, and have all neceſſaries, in common, which is an admirable thing, and which has given ſome authors occaſion to frame ſeveral parables, and make various moral reflections. It is beyond doubt that this animal they deſcribe was likewiſe a ſpecies of the Cancellus or Hermit Crab, one part whereof, that which provides neceſſaries, and creeps out of the ſhell, is covered with a hard cruſt; but that which remains within the ſhell is the ſoft and tender part of the body; and as the ſhell ſerves in this part inſtead of a ſkin or covering, there was therefore no need of a teſtaceous cover or cruſt, as we have already obſerved with reſpect to the Cancellus.

The Pinna is a ſpecies of the Oſtracodermon, and is at this time called Vinne in the Netherlands, by thoſe who have a curioſity for things of this nature; becauſe, perhaps, the animal living within ſeeks its prey by violence, and catches and kills leſs creatures with its forceps. It may poſſibly alſo have its name from hence, that its ſhell is commonly as thin as the fin of a fiſh, and when ſtript of its ſkin, is tranſparent like the ſcales of fiſhes. This ſhell is contracted into a ſharp or pointed end on one part. In my father's muſeum are many ſpecimens of thoſe ſhells, which are called by ſome prickly Muſcles.

I ſhall not deny that ſmall Crabs are frequently found in the ſhells of ſea Snails, when their inhabitants have been killed and taken out of them; nay, and ſometimes Star-fiſh are found in the ſame manner, for I ſaw this very thing in the town of Petten, on the ſea coaſt. But this happens only by chance, and theſe little animals cannot ſtay long in thoſe habitations; when hunger begins to incite, they go out for food. Thus, when I was looking for inſects, I have, in company with Mr. Thevenot, and Mr. Stenon, found ſeveral ſmall Crabs in the river Seine, in the bones of ſome ox's ſkulls which had been thrown into that river.

The ſhell in which the Hermit abovementioned lies, is on the inſide twiſted into the like windings as the operculated Wilk; I ſhall therefore omit its figure in this place. But that the diverſity of the windings may be known, in ſome meaſure, in other ſhells, I ſhall now repreſent the inward windings of the turbinated kind. The common Turbo is of a very elegant ſtructure; it begins at the baſis with broader windings, Tab. VII. fig. I. *a*, and, riſing by degrees obliquely, like a circular ſtair-caſe, converges into an acute point *b*, and thus forms various cells and lodgments.

But the figure of the Voluta, or that called the Cylinder Snail, is much more beautiful, becauſe the convolution or winding is more complicate and intricate; its entrance, fig. II. *a*, growing narrower *b* by degrees, forms another round *c*, which afterwards, being ſtill twiſted or convoluted *d* round its pillar, produces beautiful and regularly ſpiral tendrils, which grow narrower by degrees, and at length are loſt. This ſtructure truly merits admiration, for all things are there ſo beautifully divided and ſeparated by inward diviſions and cells, that they exhibit a labyrinth of miracles, into the inward cell of which we cannot obtain admittance, unleſs we firſt paſs round all theſe windings. Nor can any one diſcover its wonderful elegance, unleſs guided by the Ariadnean thread of an unwearied reſearch into the works of God. The Almighty gives knowledge as the price of labour, which the heathens themſelves have declared.

No leſs admirable are the ſinuſes of the Concha Veneris, with which the women in Holland adorn the ſtrings tied to their keys, and poliſh their whitened linen after bleaching. This ſhell is conſtructed with various convolutions, and unuſual and amazing windings, like tendrils; and to all thoſe convolutions of the inward part of the ſhell, the body is fitted and made to agree by its bendings and windings. I have already explained in the Snail before deſcribed how this is done. Its entrance, Tab. VII. fig. III. *a*, is beautifully fortified and divided into little teeth like thoſe of a ſaw; ſuch as are likewiſe obſerved to be placed on the inſide about each winding, as far as the extremity *b* of the ſhell, which terminates in a very ſharp and ſmall point. But all theſe remarkable things cannot be exhibited in a ſingle figure.

In the Penicilli Marini, which the French call pencils or plumes, the moſt wiſe architect has diſpoſed their windings in a very different manner: they begin in the orifice, fig. IV. *a*, of the Penicillus, and inſenſibly form another lodgment or apartment, with their notched or denticulated bendings; then as it were, diminiſhing by degrees, and riſing again with broader convolutions, they form a third lodgment *c*; afterwards they decreaſe more and more, and make a fourth *d*, fifth *e*, ſixth *f*, and ſeventh *g* compartment. The laſt is like a little ſtring or tuft of filaments, and is properly the firſt rudiment from which the Penicillus begins to increaſe, and whence, by a gradual augmentation, it acquires or raiſes all the reſt of the compartments.

In the cabinets of the curious, there is kept a certain ſpecies of Snails, which agrees in its internal conſtruction, well enough with the Cornu Ammonis. This conſiſts of a ſimple little tube, fig. VII. *a*, rolled into itſelf, very large before, narrower behind, and ending in a very ſmall point. It differs from moſt other ſhells of Snails, becauſe it is divided on the inſide into numerous compartments, by delicate partitions, which are tranſparent even on the outſide, 1, 2, 3, 4, 5, &c. In the fore end, the partition which is hollow like a ſaucer, is naked or plain to the eye, and has a ſmall hole pierced through it there *a* *. If this hole be accurately viewed, it is found actually to open into the tubular appendage of the partition, which appendage or tube is inſerted in the opening of the ſecond partition, and the tube of the ſecond into the aperture of the third, the third into the fourth, and ſo afterwards to the end of the ſhell.

All theſe things appear plainer, if the outward ſhell of the Snail is picked off; for then the ſtories or partitions, Tab. VII. fig. VIII. *bb*, ſituate in the Snail's tube, are ſeen very plainly, as well as the little tube or ſiphunculus, that reaches from the firſt partition to the aperture and tube of the ſecond, and the tube of the ſecond to the third, and ſo to the extremity of the Snail: all which may be ſeen about the inward ſide of the curvature *c* of this creature very diſtinctly. But ſince theſe things cannot be ſo diſtinctly exhibited or underſtood under its natural ſize, I have thought it adviſeable to repreſent, of theſe, ſeveral partitions conſiderably magnified; in which figures, the acetabulum or partition appears firſt in its compaſs, fig. IX. *ddd*, and on the inſide its inward fold, hollow like a ſpoon. On the upper part of this is ſeen *e* a little aperture formed with the moſt exquiſite art. Behind this aperture is ſeen the tubular appendage of the acetabulum or partition, which, on the upper and lower ſide of that partition, is ſtretched out, like the crooked handle out of a certain ſpoon, and is received very exactly into the aperture and tubular appendages of the partition, fig. X. *g*, and this again into the aperture and tube of the third *h*.

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* All Nautali are of this ſtructure, as alſo the Arthoceratilæ, as well as Cornua Ammonis, which are found petrified, being inhabitants of deep ſeas; whence they are never got up living, nor the ſhell ſeen recent. In the large thick Nautilus, theſe partitions are forty or more in number, and there runs through them all a pipe; this is called the ſiphunculus; the animal within is of the Sepia or Cuttle-fiſh kind. In the Arthoceratilæ they are more numerous. We ſee this ſhell-foſſil in the red ſtones called Swedes paving, and uſed in court-yards, and for flat walks.

What has been hitherto ſaid, is far from completing the artificial ſtructure of this wonderful Snail: for as this Cornu Ammonis becomes ſmaller by degrees, ſo do its partitions, and their tubes *iiii* become leſs, until at length they become inviſible. I obſerve likewiſe, that theſe tubes of the partition are not connected together, but are only contiguous, and are put into each other, in the ſame manner as the tubes of teleſcopes, which receive each other in ſuch a manner as to be freely moveable. But on the contrary, the acetabula or partitions themſelves increaſe with the Snail's ſhell, and are united to it. I preſerve ſome of theſe acetabula, which ſhew their very elegant ſtructure, if their tubes are joined together; for which purpoſe, and that they ſhould not be eaſily loſt, I keep them together bound with a ſilver thread.

This Snail therefore agrees with all others in regard to its ſtructure, and its ſhell conſiſts of one crooked tube. It differs, however, from the reſt only in that the apartments or cells are placed in a different manner, and have perforated handles: theſe may be ſaid to form the pillar of this Snail, ſince they exactly receive each other.

I never ſaw this ſhell with its Snail but empty only in my father's cabinet. I ſhould therefore be very glad to know, by what means the body of this little creature, which inhabits that ſhelly houſe, is placed there, and whether it extends through all thoſe apertures from cell to cell, and is interſected, as it were, in ſo many places; or whether it lives only in the extreme apartment, and is inſerted with its muſcles in the tubes of the ſhell. But however much I wiſh to be gratified in this particular, I ſhall never, probably, accompliſh my deſire. It would therefore be proper for thoſe who viſit foreign countries, for the ſake of commerce, to import ſuch things; for though they have never ſo little curioſity or taſte for theſe ſtudies, they ought to endeavour to make the works of God manifeſt to poſterity, and by due care they might profit more than by any other means whatſoever.

The great Indian Nautilus is nearly of the ſame ſtructure with the Cornu Ammonis, and therefore I had once thought to give its figure in this place: but ſince it is found in many of the cabinets of the curious, and of the ſame ſtructure with this, I ſhall deſiſt from my intended purpoſe, and the rather, becauſe the celebrated Aldrovandus has left us a pretty neat and exact figure thereof.

Let it ſuffice, that I have annexed the figures of the two tubular Snails, or teſtaceous tubes already deſcribed, which afford an example, from which the manner of conſtructing all the ſhells of Snails may, in ſome meaſure, be underſtood. All the difference obſerved between them ariſes from the variation of their convolutions only: to which, if we further add ſome outward ornaments of ridges, hollows, windings, plains, tubercles, depreſſions, extenſions, impreſſions, and colours; and laſtly, that the cavity of the pillar ſometimes grows together entirely, as I have likewiſe ſometimes obſerved in the ſhell of the garden Snail; it is then eaſy to reduce all the geometrical figures, curves, oblique and right angles, in all kinds of Snails, to one ſpecies, that is, to an oblong tube, which is curved, curled, or bent in and out, and grows in this ſtate.

The tubular ſhell-fiſh before-mentioned*, exhibits the moſt ſimple articulation of all the kinds, for in their beginning they are ſtretched out, like a plain tube, Tab. VII. fig. v. *a*, or little inteſtine, and are turned or bent round moſtly near the end *b*. And hence ariſes that cavity, fig. VI. *c*, whereof I ſpoke, when I treated of the cavity of the pillar. But theſe tubular creatures grow together, ſometimes ten or twenty, in ſo perplexed a manner, that nothing certain can be diſtinguiſhed concerning them, ſince nothing appears to our view but ends or tops, windings and little apertures.

I ſhall further add, that almoſt all kinds of Snails and ſhell-fiſh are twiſted towards one and the ſame ſide; nor can many be found, at leaſt very ſeldom, the convolutions whereof go, Tab. VII. fig. XI. *a*, in a direction contrary to the others. In ſome ſpecies of oval Turbo's, and ſome others, this is ſometimes found; and ſuch ſhells, for this reaſon, that they are leſs common and more eſteemed, are carefully kept in the cabinet of the curious.

The little Turbo.

I found ſome years ago a ſmall Snail between the bark and wood of an old willow-tree, the ſhell whereof reſembled a ſea Turbo, and from a ſomewhat broad beginning, terminated Tab. VIII. fig. I. *a*, inſenſibly in a ſharp-pointed top. This Snail is never ſeen in the day time, except in rainy weather; it then always hides itſelf under the bark, or in other ſhady places, and reſting there, it faſtens that part of its ſhell by which the body creeps forward, to the wood, the other acute extremity being obliquely directed upwards. The ſhell of this Snail is likewiſe curled or convoluted in an inverſe manner; and what merits great notice is, that its genital organs are placed in the left ſide of its neck, in an order contrary to all other Snails. But I have ſometimes obſerved the convolution of the ſhell to be inverted in the Purple-fiſh. It is therefore probable that whatever Snails have their ſhell twiſted in an inverted manner, have likewiſe their genitals in the ſame ſituation.

I have very ſeldom ſeen this Snail with its ſhell larger than I have expreſſed it in the figure; nor have I found that part *b* of its body, which creeps therefrom, larger than there ſhewn: for when this part turns out, it carries its little ſhell like a pyramid obliquely on its body. It has four horns, whereof the two upper ones have their eyes in their extremities. The two lower do not appear ſo diſtinctly, being only two obtuſe or blunt little ſwellings. The two upper horns and the eyes are large, in proportion to the bigneſs of the creature. The aperture of its verge, through which it breathes, is likewiſe in its left ſide. Its ſhell is twiſted into ſeven ſpiral lines, and is adorned on every ſide with little ribs or ridges, ſo that, by this means, very beautiful wrinkles or folds appear in this ſhell, which has likewiſe its perioſteum to cover it.

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* Theſe are called Tubuli Marini by authors: they are ſimple and plainly hollow. Some are ſtraited, and others ſmooth on the ſurface; ſome perfectly ſtrait, others twiſted at the end. They are found looſe on the ſhore, and lodged in ſolid ſubſtances. The animal within is a true Snail.

The internal parts of this little creature agrees in general with thoſe of the common covered Snail. The parts of the jaws, mouth, and palate, and all the ſalival veſſels and the ſtomach, are alike in both. The brain lies on the gullet, and may likewiſe be beautifully diſtinguiſhed, but in its ſtructure it approaches more to the brain of the common water Snail, which I have repreſented in Tab. VIII. fig. IV. Its pointed liver fills the extremity of the ſhell, and, like the latter, it is likewiſe twiſted, but its ſtructure is glandulous. The orifices for the penis and uterus are opened in the left ſide, ſo that the penis, erecting itſelf, ſprings from a place directly oppoſite to that in the common Snail. But it appears from this perfection of the genital parts, that the creature, though ſo minute, has already attained its full ſize. The ovary likewiſe appeared to me pretty diſtinct. The purple ſacculus or bag, was likewiſe very viſible, as well as the little part in the form of a chain.

I preſerved this Snail alive ſome days, by giving it lettuce in a glaſs veſſel, into which I had poured alſo ſome drops of water, during which time it moved the whole day. At other times, when the weather is hotter, this ſpecies eat chiefly at night. In the month of June I found it under the bark of willows.

If its ſhell be viewed with a microſcope, the aperture, Tab. VIII. fig. II. *a*, of the inverted twiſt, through which the body paſſes, and the opening *b* of the pillar, and the ridges of the ſurface, or the ribs *ccc*, appear clearly to the eye.

The ſmall flatted Snail.

Under the bark of willows is likewiſe found another ſpecies of ſmall Snails, the ſhell, fig. III. *a*, of which is ſomewhat of a more ſimple ſtructure, and ſo thin that it is all over tranſparent. The Snail contained in this died for drought before I could diſſect it. Its ſhell was all tranſparent, by reaſon of its exquiſite fineneſs; ſo that the dead body of the Snail appeared through it, diverſified with ſome colours and ſpots.

The oval Snail.

In the ruſhy graſs of ditches, and on the water-lilly, when its leaves reach to the ſurface in rivers, there is found a certain ſpecies of Snails, which reſide there on account of the cool air and moiſture, where they may at any time ſeek out for their food: but they go to feed chiefly late in the evening and early in the morning, and in the heat of the day they remain quiet near each other under the ſhade. Their ſhell which they carry on their bodies, is of an oval figure, marked with many hollows or furrows, and adorned, Tab. VIII. fig. IV. *a*, with a perioſteum of a pale red colour. The hinder part is ſo tender, that when roughly handled, it is very eaſily broke, and this is rolled into a double ſpiral part *b*. The body of the creature that creeps *c* out from thence is marked with points or black ſpots, and in the fore part it ſtretches out two blunt or obtuſe *d* horns, under which are ſeen two others ſmaller.

In the mouth of this Snail is a pretty ſtrong tooth, which is extended into a horny little bone, and expands itſelf through the whole inward part of the mouth. The aperture of the verge is on the right ſide, and the orifices of the genital parts open at the ſame ſide in the neck. The ſtomach is of a pale colour, and is variegated with black points or ſpots; hence it appears upon the whole gray. The ſalival veſſels which run near the gullet under the brain are very remarkable and large, in proportion to the ſize of the animal, and are ſpeckled or ſpotted like the ſtomach. The liver is the ſame as in the common Snail. The heart is placed in the left ſide, and there lies the lime bag alſo, which is very large, and full of round white globules of various ſizes. The brain and nerves are like thoſe of the common covered Snail. The penis appears ſhort, but if the membrane, by which it is erected, be opened, it is found bent on the inſide like the tendril of a vine, and is ſeen to be really very long. The ſtructure of the uterus is the ſame with that of the common Snail; but on one ſide of it is a ſmall part that I never ſaw in that Snail. After this follows the yellow ſacculous bag deſigned for the glutinous moiſture; and at length the ſmall part in the form of a chain, which is very black like pitch. The purple pearl-eyed little knot appears half round in this Snail, though it is really ſomewhat oval. I could not diſcover more parts in this little creature, though I obſerved that it had the ſame muſcles as the common Snail; nay, that two of them were deſigned to paſs underneath through the brain, for the purpoſe of drawing in the parts before mentioned.

CHAP. XIII.

Of the garden Snail, the houſe Snail, and that of the fields or path ways.*

ALL the external and internal parts of the garden Snail, which is a handſome little creature, are the ſame with thoſe of the larger Snail, only that they differ a little here and there in reſpect of ſtructure and colour. Since therefore the difference is not ſo great in regard to the reſt, I ſhall here briefly explain the only one that is in the genital parts. The aperture of the genital organs, Tab. VIII. fig. V. *a*, is placed in the neck, ſomewhat lower than it is in the larger Snail. The uterus *bb* and its ligament *c*, and the bag which holds the glutinous moiſture, are like thoſe of the larger Snail *d*. There is, moreover, no difference in the chain-like little part *e*. As I began this inquiry in the month of June, which was indeed far advanced, the little eggs *f* were ſeen more diſtinct in the ovary, near the extreme ſpiral part *g* of the liver; theſe eggs were, in my opinion, to be carried from thence through the chain-like little part into the uterus, and to be covered all over with the glutinous moiſture. The purple little knot *h* was of a colour almoſt approaching to a pale yellow, and contained a ſtronger ſubſtance than in the larger Snail. The other tube or pipe *i*, which in the larger Snail opens into the uterus, was in this ſtretched out further, and the alcaline little bone was, in a ſituation directly contrary, thruſt into it. In the larger Snail, likewiſe, I have found this tube ſometimes in the ſame ſituation. This little part was moreover formed, where in its beginning it is connected with the uterus *k*, in the ſame manner as it is in the larger Snail. The imperforated appendage *l* of the uterus has likewiſe the ſame ſtructure, but is of a more gray colour: the teſticles *m* likewiſe, were like thoſe of the covered Snail, but conſiſted of longer filaments, and were divided only into ſix veſſels. The alcaline little bone *n* was of a ſtructure entirely different, and wanted thoſe four little ribs, which I have before exhibited in the magnified bone of the larger Snail, but was very beautifully decorated with little holes, and little prominences that met all together. It was however full as big as the little bone of the other Snail, and may likewiſe be ſtretched further out of the body, for it ſtood on a longer little knot, the neck whereof was much longer, and likewiſe of a gray colour. The penis *oo* ſeemed longer and more acute, and I have here delineated its only muſcle, Tab. VIII. fig. V. *p*, which draws it in. This was placed in the ſame manner as in the large Snail. Moreover, the common duct *q* between the penis and uterus did not differ in reſpect to its ſtructure. But this Snail twiſted about the ſharp end of its penis in the diſſection, and curled it into various turns *r*, which I never ſaw ſo clearly and diſtinctly in the other Snail.

There is great difference between the manner of coition in the larger Snail and this of the garden; the penis of this latter is rolled out further, and is more erected and much longer; it has at its origination the ſame glands the ſkin is provided with. The coition of the garden Snail continues longer than that of the larger Snail. And the whole penis of one Snail is put as far as its extremity into the body of another; hence theſe two penis's are ſometimes ſeen, fig. VI. *a*, twiſted together in a very wonderful manner. But this winding is not ſeen ſo beautifully as I have delineated it, unleſs the Snails are drawn a little aſunder; for then is perceived the wonderful manner whereby the penis of one Snail *b* rolls itſelf round the penis of the other, and enters into the uterus *c*, whilſt the penis of the latter is, in its turn, twiſted round that of the former *d*, and likewiſe put into the orifice of that creature's uterus *e*. But if theſe Snails are pulled away from each other at the time of coition, the whole penis's, long as they are, being drawn from the orifice of both Snails appear in ſight, and each creature afterwards turns them in in a wonderful manner, and after a ſhort time draw them back again into the body.

But as each Snail has its genital parts in the right ſide of the neck, their heads are applied to each other croſs-ways at the time of coition, and conſequently the body and horns of each Snail have a contrary ſituation at that time. For in the body of the former Snail *f*, the opening and diviſions of the verge whereby it draws the air, are viſible; but in the latter Snail nothing is ſeen of them *g*, for this Snail is placed in a different manner.

Theſe garden Snails are of the moſt common kind. Their ſhell is grounded on yellow, and is divided lightly by ſpecial ſmall furrows; it is alſo adorned with tawny or black rings, which ſurround it nearly in the courſe of the ſhell's ſpiral turns. It is alſo covered with a very thin membrane or perioſteum, which is black or yellow in the ſame places where the ſhell itſelf is painted in that manner, and it likewiſe preſerves its colour when the membrane is taken from it.

Each of theſe Snails has alſo four horns, of which the two upper ones only have eyes.

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* The ſpecies here meant by the author, is the common ſmall painted Snail, which we find in hedges. We uſually call the larger brown kind the garden Snail, becauſe it is more common with us in gardens; but this the author calls the common Snail. This leſs being more frequent in the gardens of Holland, is the garden Snail of that country.

It was therefore an idle fancy in ſome perſons, to think that the Snail uſes its horns, as a blind man does his ſtick, that is, to find out the way it is to creep through, or to try and diſtinguiſh, by its touch, whether objects are hard or ſoft. The head of theſe Snails, in that part of it where the lips are ſituated, reſembles, in ſome meaſure, the head of a cat; and when well viewed, it appears like it in ſeveral reſpects more evidently.

The common houſe Snail.

The naked houſe Snail, which is found in moiſt cellars and about the tops of ciſterns, is naked and has no ſhell, but is covered with its skin only. In this particular it agrees with that part of the covered Snail, which creeps out of the ſhell. On the outſide it is provided with four horns on its head; the two uppermoſt whereof have eyes at their extremities, Tab. VIII. fig. VII. *aa*, which are ſituated a little within the margin, on that ſide which lies towards the eminence placed on the back. The two lower horns *bb* are ſmaller and have no eyes. There is further ſeen on its body, that eminence or velabrum *cc* which is fixed to the back, and runs along the reſt of the body; and the body is furniſhed with oblong, acute, and tender glandules, and variegated with black lines and ſpots. But the horns, head, neck, and whatever reaches beyond the eminence, are adorned with many ſmaller and more delicate glandules. On the right of the declivity of the neck appears an apperture *d*, through which the genital organs puſh themſelves.

The eminence on its back itſelf, is of a different colour from the reſt of the body, for it is adorned with chanelled or creſted little grains, and it is moreover very beautifully variegated with black ſpots. This is not common to all houſe Snails, for they differ much in colour. Towards the fore part, at the head, the eminence is looſe and free, but for the moſt part, it is kept very cloſe to the body, unleſs when any one provokes or vexes the Snail in that place; for then it raiſes and moves it different ways; and I have, for that reaſon, drawn it as elevated in the figure. On the hinder part, towards the back, the eminence is very ſtrongly joined to the body; but in its right ſide opens an aperture, Tab. VIII. fig. VII. *e*, whereby the Snail draws air and breathes, and diſcharges its fœces; for which uſes the verge is likewiſe appointed in the covered Snail, and with this verge the eminence agrees very much, ſo far as it is placed on the fore part of the body. The hinder part of the body is not very remarkable, only in reſpect of the different ſtructure of its glandules. Moreover, in both ſides of the body is obſerved a ſmall, black, unequal margin. In fine, there is on the hinder part, above the tail, a prominent ſubſtance *f* like a Cock's comb, which is indeed diſpoſed in a different manner in the field Snail. The Snail ſecretes a glutinous humour from this part.

If any one opens the eminence at the mouth of the air paſſage with a little pair of ſciſſors, he will ſee that the inward skin is made on the inſide like a net; which ſtructure ſeems to be produced by the veſſels diſtributed through it, as I have likewiſe before ſhewn in the verge of the covered Snail. This little net may be ſeen very beautifully through the aperture of the eminence on a clear day, when the Snail opens it; for the creature can contract it ſo cloſely, that not even a veſtige of an aperture appears. In the cavity of this eminence, on the left ſide of the body are ſeen the heart, which beats, together with its auricle and pericardium, and likewiſe other cavities through which the air paſſes. But when you remove this little net from its place, you will ſee a ſmall ſtone underneath, which is called, by authors, Lapis Limacis, the Snail ſtone, and is ſaid to ſerve for various uſes in medicine. This little ſtone may properly be called the os thoracis, or breaſt bone of the creature, for it is placed in the middle of the thorax and back. It is of the figure of a ſmall hollow, and ſomewhat long ſhell, fig. VIII. *a*. and being connected in its circumference with various membranes, and on the upper ſide with the little net, it is thus kept in its place. It is ſometimes obſerved to be altogether membranous, but ſometimes it is pretty thick and all ſtony, and it ferments with an acid; at other times, again, it becomes ſtony only here and there, and is obſerved to be interwoven *b*, as it were, with veſſels which are filled with ſtony little grains. Hence one may underſtand the manner of its production, which is from the coagulation of the ſtony particles; in like manner as is obſerved in the membranes which the covered Snail frames, when it lies ſome time at reſt. Theſe ſhelly ſtones are found in younger, as well as full-grown houſe Snails, and I have ſometimes found in the largeſt, very ſmall and membranaceous ones, interwoven with various petrified veſſels; and often in ſmaller ones, I have found them formed of ſolid ſtone. Hence I am inclined to think, that the Snails change this their little ſtone yearly, in the ſame manner as Craw-fiſh change thoſe two ſemi-convex and plain ſtones, which are likewiſe placed in their thorax, and are improperly called Crabs eyes.

Near the heart is obſerved a ſacculus calcarious, or lime bag, not much different from that which we have deſcribed in the large Snail. Afterwards the ſtomach, inteſtines, and genital parts preſent themſelves in the abdomen. The ſtomach is indeed pretty large and ſtrong, and conſiſts of three diſtinctly viſible coats. The innermoſt is wrinkled into plaits, and is of a yellow colour; the middle one is muſcular; the outermoſt is ſomewhat corrugated or rough, with very beautiful partitions, eſpecially when the ſtomach is empty. Directly before are ſeen the ſalival veſſels, which, as well as thoſe out of which they ſpring, are ſhorter than in the larger Snail, but they are of the ſame texture. The inteſtines paſs twiſting or winding

ing through the liver, which is placed between them, but they are much leſs rolled and turned in this than in the larger Snail, ſince they are ſtretched according to the length of the body, and are not obliged to follow the convolutions of a ſhell. The liver is divided into many lobes, and conſiſts only of minute glandules.

The genital parts in this Snail are worthy of particular notice, ſince they fill the whole belly: but I ſhall treat of theſe hereafter, when I ſhall briefly deſcribe the parts of the head, neck and breaſt. The head preſents a tooth, viſible in the mouth like that of the larger Snail, and all the parts of the mouth are alſo formed in the ſame manner as we have there related. The brain likewiſe, the ſpiral marrow, and the nerves, which are placed in the neck, do not differ much, and are eaſily diſcovered. The muſcles which move the upper horns inward, are much more brown or blackiſh than in the larger Snail; but the reſt, and likewiſe thoſe which paſs through the thorax, have ſome fleſh, as well as their white tendons, and are both inſerted in the ſkin, which is very thick, and where the eminence lies: nor are there any bones in the Snail, in which the muſcles ſhould be inſerted. A muſcle is therefore here inſerted in a muſcle, and one dilates another, which is a very admirable thing to ſee in animals.

The organs of generation in this Snail, open by three diſtinct apertures in the neck, Tab. VIII. fig. IX. *a*, which unite in one paſſage on the outſide. The firſt opening is peculiar to the penis *bb*, the ſecond to the uterus *cccc*, the third to the purple bag, which is very ſhort in this Snail. The penis is ſtrong and very nervous, and it lies in a little kind of a purſe, which may be diſtended by the breath, that the penis may roll itſelf out from thence. On the hinder part or ſide of the penis iſſues a ſmall filament *e*, which is connected with that of the uterus *fff*. This ligament of the uterus abounds with many granules, which are white, and unequally divided; thoſe, at firſt ſight, I took for the ovary in the larger Snail, thinking that the little eggs were conveyed through certain hidden channels out of it into the uterus: but I now obſerve, that it has a peculiar kind of tube in this Snail, which opens into the hinder part of the cavity of the penis, and conveys its matter into it. The uterus wraps itſelf round this ligament, and is greatly ſtrengthened by its connexion therewith, though this connexion is formed in the beginning only by ſmall intervening membranes.

The uterus in the Snail which I diſſected, was very much diſtended and ſwollen *gg* with little eggs; nay, its texture ſeemed more ſtrong and firm, than when nothing is found in it. On the hinder part lay the glue-bag *hh*, very much dilated and expanded into lobes, which were again ſtudded in a peculiar manner. When I viewed them with a microſcope, I obſerved, that they were all full of very ſmall ſpheroidal globules, whereof ſome were bigger than others. The chain-like little part *ii* was ſtretched ſtraight, or upright enough. The ovary was fallen down *k*, and deprived of its eggs, ſo that nothing was left in it but the membranous incloſures. All the eggs, in my opinion, had deſcended through the chain-like tube into the uterus, and were to be immediately there covered with moiſture, by means of the ſaculus that ſecretes that fluid: this I ſhall explain more at large, when I ſhall ſpeak of the field Snail. Nor did the eggs, notwithſtanding, fluctuate freely in the uterus, but they all lay firmly fixed on one ſide, which makes me ſtill doubt to advance what I have ſaid of the ovary and eggs as true and certain. But I hope theſe things will hereafter be made plainer. I ſhall therefore proceed to the field Snail, the anatomy of which will throw great light on this matter.

Of the field or path-way Snail.

The common Snail of the path ways and fields differs from the houſe Snail, chiefly in reſpect of the ſtructure of its external ſkin, and in a peculiar kind of verge which ſurrounds its body; to which may be added, the fiſſure that is in the extremity of its tail, out of which a certain glutinous humour is ſecreted: but there is no difference in the internal parts. I have delineated the field Snail, which I here exhibit, in the form it has when contracted. Thus its two largeſt horns, Tab. IX. fig. I. *a*, may be ſeen, except a ſmall part thereof, which is covered by the eminence or velabrum. On the right of this velabrum is ſeen an aperture *b*, whereby the Snail draws the air and diſcharges its excrements: the ſame may be obſerved likewiſe in the houſe Snail. In the cavity of the eminence, the ſkin is alſo white and reticulated, as it is in the houſe Snail. The external texture of this eminence conſiſts of fine glandular granules, or little grains, which are far from being orbicular; they are ſtriated as it were, and rendered unequal by ſome tubercles, though theſe ſtriæ or furrows are not as remarkable in this as in the houſe Snail. The reſt of the body is furrowed as with pretty conſiderable wrinkles; hence it is that many glandular protuberances appear in it, which are of a triangular form, and riſe up obliquely, and are divided *cc* by many ſmall glands. The body is, moreover, adorned with a full, or gloſſy, red verge *dd*, which is beautifully divided and ſubdivided by black furrows, ſome of which therefore are more conſpicuous than others. This Snail can extend itſelf to three times the length that I have here repreſented; and then the diviſions of the ſkin before deſcribed acquire as it were another form, by the force of its expanſion. The whole body is of a deep brown, mixed with a ruddy colour; but theſe Snails differ very much with reſpect to their colour.

As its internal parts are organized, and circumſtanced much in the ſame manner as in the houſe Snail, I ſhall now briefly deſcribe only the ſtructure of the genital organs, and add the conſtruction of ſome of the internal parts, which I have here alſo delineated. The genital organs are thruſt out of the neck, in the ſame manner as in the houſe Snail, and are found to be likewiſe placed behind the parts of the palate and mouth, Tab. IX. fig. II. *a*. On each ſide the larger horns *bb* may be ſeen when drawn in; they appear under the divided ſkin of the head. Behind the proper parts of the mouth, and above the gullet *d*, is placed the brain *e*, which is formed of two ſmall parts like globes, applied cloſe to each other. Immediately after appears the origin *f* of the ſtomach, together with the ſalival veſſels *gg*, which are here repreſented as clipt or cut off near the gullet. After theſe are obſerved two glandular corpuſcles *hh*, from which the ſalival veſſels ariſe. Then at length is preſented to our view the ſtomach, with its veſſels *i*, which are of a pure white, like the colour obſerved in the inteſtines *kk*. The windings of the inteſtines ſurround the liver *lll*, which conſiſts of ſmall glandules, equally divided and interwoven with very white veſſels. It ſends forth the gall-bag *m*, which is large, and diſcharges itſelf into the ſmall guts that are next to the ſtomach.

The beginning or rather end of the genital organs is ſeen in the ſkin *n* of the neck, and their mouth or opening appears there in the outward ſkin; which, however, I have not exhibited in this place, that the other parts might be the more diſtinctly viſible. The firſt thing that preſents itſelf is the penis *o*, which, being twiſted like a tendril of a vine, opens with a kind of tube *p* into the cavity of the uterus. Nothing of this kind is obſerved in the houſe Snail, but in the covered Snail there is likewiſe a common duct, and the penis is extended longer. Behind the penis is ſeen a remarkable pear-ſhaped bag *q*: this is the purple-bearing bag; it is very large in this Snail, and contains a delicate juice. It opens by a ſmall tube *r* into the cavity of the ſkin of the penis, by means of which the latter erects itſelf.

The origination *s* of the uterus is pretty thick and ſtrong, and after it grows ſmaller *t*, it twiſts and bends itſelf, and goes into the body of the uterus *uuuu*, as it does in many other Snails. But the ligament of the uterus is not ſeen in this; its place is occupied by ſeveral whitiſh veſſels, which are connected *xxx* by a ſmall kind of membrane, that ties the curled windings of the uterus. About the end of the uterus, where the bag of glutinous moiſture *yy* is joined to it, is ſeen a place where the chain-like tube is inſerted, or fixed in the uterus: nay, it further appears, how this tube runs through and over the liver, and under the ſmall guts *α*, and is connected with the ovary *β*, which is here empty. This ovary is divided into two parts, as it is in other creatures. The diviſion, however, is not ſo remarkable in thoſe Snails, which have not exerciſed venery, as it is in the ovary, which I here exhibit alone, fig. III. *a*. I therefore repreſent this ovary big and expanded, as I think I ſaw it ſome months after coition. For it is then obſerved, that this little part conſiderably increaſes, Tab. IX. fig. III. *a*, and that the eggs *bb* are made viſible therein. I have likewiſe obſerved this increaſe in the ovary of the ſhelly Snail. But the eggs, it ſeems, are afterwards diſcharged out of the ovary, and deſcend through the chain-like little tube *c* into the cavity of the uterus, to the hinder part of which the former is joined, fig. II. *z*. But as the paſſage of the eggs is ſo near to the bag of glutinous humour, I therefore think, they are there covered over with a little of it, and that when they grow larger, they get more of it, and, at length, attain their full bigneſs in the uterus. But I could never hitherto find eggs in the chain-like little part, as I have already mentioned in the deſcription of the houſe Snail; nor could I ſee that they are conveyed through it. I ſhall therefore defer advancing this opinion as an undoubted truth, until I ſee it myſelf; though I think, at the ſame time, the matter may moſt probably happen ſo. The heart likewiſe is ſeen in its natural ſituation *γ*, as alſo the manner in which it is ſurrounded by the bag *δδ* of calcarious or limy matter.

CHAP. XIV.

Of the common water Snail, alſo, of an uncommon and viviparous kind of water Snail; and of the flatted water Snail, and the muſcles of the river Vecht. Alſo a remarkable obſervation on the common Snail.

THE common water Snail, which I find every where at the edges of ditches in Holland, differs much both from the common covered, and from all other Snails. It is diſtinguiſhable, not only in regard to the outward ſkin or ſhell, but alſo with reſpect to its eyes, and the apertures both of the verge and the genital organs, which are all conſpicuous on the outſide. There is alſo a ſtill greater difference in the internal parts; all which I ſhall now briefly enumerate.

The ſhell, which is in the form of a ſpheroid in the large Snail, is in the water Snail rolled in an oblong form like that of the Turbo, Tab, IX. fig. IV. *a*. But there is ſtill a greater difference in its eyes; for as the latter in the common Snail are at the ends of the horns; on the contrary, they are found in this aquatic or water Snail, to be ſituated at the bottom or baſis *bb* of them, but they are not provided with any viſible muſcle to move them. Even the horns themſelves, which end in ſharp points *cc*, are only weakly drawn in occaſionally in order to become ſhorter.

In ſome of theſe Snails, I ſaw with amazement that there were two eyes, placed near each other on the right ſide of the creature, each of which was provided with its own proper chryſtalline humour. This, I think, is very remarkable, and ſtrongly demonſtrates the manner wherein the eyes may be multiplied in inſects, as I ſhall hereafter demonſtrate, when I ſhall treat of Bees. The nerves of the eyes in this water Snail are leſs viſible than in the common kinds; nor do they ariſe immediately, as is ſaid, from the brain, but from a little nerve which lies towards the fore parts of the head. In other reſpects the eye itſelf does not differ from that of the covered Snail, only that it is bigger, and in a manner pear-ſhaped, or like an onion. The chryſtalline humour is likewiſe larger in this, however diſtinguiſhably leſs the little creature may be in itſelf.

The opening *d* of the verge is very worthy of conſideration, and has divers muſcles, by which it is dilated and contracted. The Snail ſometimes gathers this aperture into an oblong tube, and ſtretches or protends it above the ſurface of the water, in order to draw in and expel the air. This may not only be ſeen but heard alſo, by the noiſe which the Snail makes in moving the water. Nay, by the aſſiſtance of this aperture, through which the air is conveyed into the inmoſt ſurface of the membrane of the verge, and into the cavity of the body itſelf, the Snail makes a beautiful figure ſwimming in the water.

This creature can likewiſe immerge or dive to the bottom of the water, if it compreſſes the internal air. This is effected in the ſame manner as when the air is compreſſed in a glaſs with water in it; for little perforated glaſs globules ſwim at firſt in the water, by the aſſiſtance of the air contained in their cavity: all theſe little globules ſubſide as ſoon as the ſmall quantity of air contained in them is condenſed; which happens by the common preſſure of the air, that is above the water in the glaſs; but they emerge or riſe again to the ſurface, as ſoon as the finger or any thing that ſtopt it, is removed from the mouth or orifice of the glaſs. This is a pleaſant experiment, and I have found it very true, according as it has been deſcribed by Cornelius Conſentinus, in his platonic circumpulſion.

In the ſame manner does this Snail ſometimes dive under water, and again ſwim to the ſurface, by properly managing the quantity of air in its body in ſuch a manner; the latter, being as heavy as the water, it can difficultly be ſupported on the ſurface, and is again depreſſed to the bottom by the leaſt compreſſion of the internal air. But when the Snail expels all the air out of its body, which it will do if it be pricked with a ſharp-pointed little needle, it will not then be able to ſwim up to the ſurface of the water, but by creeping ſlowly. So that from hence it is probable this creature would die, if any thing like it ſhould happen in dirty or miry ditches; ſince, in that caſe, it could not reach the ſurface of the water, until after ſome days, and would therefore be ſuffocated for want of reſpiration.

There is likewiſe a great difference, with reſpect to the external ſkins or coats of the genital organs; all the parts of generation in the covered Snail iſſue out of one opening only, whereas in this aquatic or water Snail, all thoſe parts and the entrances or mouths of each are diſtinct. The penis indeed rolls out and erects itſelf from the neck through a peculiar aperture. Tab. IX. fig. IV. *e*. But the opening of the vulva is diſpoſed, by the wiſe Architect, immediately under the tube of the verge *f*. The verge itſelf likewiſe differs greatly from that of the common Snail; it is ſmaller, more hollow, and capable of greater motion; but then it is fitted on the inſide to every part of the extremity of the ſhell *gg*, in the ſame manner as it is in the common Snail. The tooth *h*, and little tongue which is ſeen under it, are of the ſame texture in this as in the common Snail; unleſs that the tooth it more equal, and not divided into ſo many conſiderable notches.

The internal parts likewiſe differ much both in colour and ſtructure: but the greateſt difference is in the ſtomach, which is membranous in the covered and other Snails, as it is in men and in quadrupedes; but in this water Snail it is of the ſame ſtructure in all reſpects with that of the Hen or Cock kind; ſo that one would think the real ſtomach of a Hen is here repreſented, without any difference, but that it is much ſmaller. Moreover, the colour of the craw or crop is a dark or obſcure gray. The gullet of this paſſes likewiſe the chink or crevice of the brain, which is a very agreeable ſight in this admirable creature. For ſince the ſwellings or productions of the ſpinal marrow, are, by the addition of a certain heterogeneous yellow matter, here diſtinguiſhed, all theſe parts are therefore the more diſtinctly viſible. Hence it is, that one may, with greater eaſe and certainty, eſtabliſh the anatomy of the water Snail, than that of the covered Snail; for in the former are many coloured parts, by means whereof the muſcles, and many other parts, eſpecially thoſe of the palate and mouth, may be eaſily diſtinguiſhed.

The ſalival veſſels of this are like thoſe of the common Snail. The liver is likewiſe compoſed of viſible glandules, and rolled into the like ſpirals. The heart alſo, with its pericardium, is placed in the ſame order. The veſſels on the verge, on the contrary, are not ſo diſtinctly viſible. The lime bag is of a pale orange colour. All the muſcles are inſerted in the outer part of the ſhell and its pillar.

The organs of generation likewiſe differ: the penis in this water Snail is very broad; it is like an oblong tongue, and reſembles, in ſome meaſure the penis of a Drake. The muſcles likewiſe are ſtronger, and more diſtinct and numerous than in the common Snail. The uterus is divided into three parts, and opens with two mouths into another, which is under the verge; The firſt part is of an aſhy gray colour, and like the belly or rough tripe aforeſaid in beaſts that chew the cud; then the uterus becomes more glutinous, and receives ſome expanſion from the chain-like tube; to which likewiſe adheres the bag of glutinous moiſture, and alſo another little part which may be taken for the ovary. Moreover, the chain-like tube is larger here, but where it is connected with the ovary and liver, it is of the ſame ſtructure as in the covered Snail, unleſs that thoſe white ſtuds, which I obſerved in the covered Snail, are of a yellow colour in the water one. The purple little knot is alſo here of a full orange colour, and opens into the vulva by a ſingular kind of tube, as in the naked Snails. I have not ſeen the egg, but I ſaw ſome relaxed, round and tranſparent little parts in the body, which I thought to be properly glandules. Under the organs of generation, near the ſtomach, I obſerved a certain ſtrong plait or fold of veſſels, of which a conſiderable number were detached towards the liver.

The ſtomach, when opened, very beautifully exhibited its two ſtrong muſcles, and in its cavity were found ſome hard ſeeds of water plants; by the help of thoſe the Snail probably grinds its food, as Hens and Pigeons do with little ſtones, bits of lime, and other things which they devour. I have been informed that a Duck or Drake has ſwallowed a piece of gold, called a piſtole, and diminiſhed it by attrition to ſixteen grains; and hence aroſe the ſtory that the Oſtrich can digeſt iron, as Harvey well obſerves.

The food which theſe Snails moſt eat is water plants. I have maintained them for ſome days with lettuce, with which they were ſo greatly delighted, that they eat all the larger leaves of it when they had been ſome days without food. But they were then continually thruſting out their tongues, from which I concluded that they were hungry. I likewiſe fed the Snails ſometimes with ryebread, which they would greedily feed on, if it was firſt ſoftened with water. At theſe times may be very diſtinctly ſeen the manner of their eating, eſpecially if the bread be cut into fine thin pieces. The next day, after I had laid this bread before them, they prepared for generation; ſo that I ſhould conclude from thence, that bread yields them the moſt copious and effectual nouriſhment. The Teredo or Worm which eats ſhips bottoms, is alſo delighted with bread.

On the ſhell of this kind of Snail, I have ſometimes found a great number of eggs, which were laid by another Snail of the ſame ſpecies. They lay incloſed in an uniform, oblong, and pellucid glutinous ſubſtance, and they were likewiſe tranſparent as chryſtal; but after a few days there appeared in the middle of them a very ſmall gray Snail, which continually rolled or turned about in the ſame manner, as a bit of wax does in a bottle full of water, when the bottle is gently turned up or inverted. Almoſt in the ſame manner did this water Snail turn ſpontaneouſly in its ſhell, and ſwimming in a limpid humour or moiſture, ſeemed to adhere to no place. The third day after theſe eggs were laid, the Snail contained in them began to grow yellow, and afterwards they became gray.

This Snail ſwims with the ſame body, Tab. IX. fig. IV. *ii*, with which it iſſues out of its egg. This is done in the manner following: firſt, the Snail lies upon its back in the water, and turns the whole length or level of its body againſt the ſurface of the air that preſſes on the water, and having afterwards firſt bent its whole body, it moves it forward in the ſame manner as the common Snail does; and by this means, ſwimming in the water, this creature goes forward, though very ſlow, and affords a very agreeable ſight. But leſt the heat of the ſun ſhould injure it, the little creature ſecretes a quantity of mucus or glutinous humour out of its body, by the help of which it is defended from the injury of the diurnal rays, and is rendered more fit for ſwimming; and it can move and turn itſelf to all parts in the water as occaſion requires.

In order to diſſect theſe Snails, it is neceſſary firſt to take them out of their ſhells; then they will die in two days, and are ſo much ſwollen with the water which they imbibe, that their organs of generation ſometimes come naturally in ſight, and their diſſection may eaſily be perfected. But if you wound thoſe parts which moſt abound with the glutinous humour, nothing can be done to any purpoſe afterwards.

I have delineated this Snail in the form it is in when it creeps near the ſide of the glaſs in the water, and aſcends to the ſurface; and there, having lengthened the aperture of its verge, Tab. IX. fig. IV. *d*, as into an oblong tube, and ſtretched it out of the water it breathes.

The wonderful viviparous chryſtalline Snail.

The miracles which I am now going to advance of this water Snail ſeem ſo incredible, that I ſhould not wonder if they ſhould be deemed impoſſible, or reckoned among the fabulous tales of the poets metamorphoſes. For my own part, though I ſaw them, I was ſo aſtoniſhed on this occaſion at the inexhauſted fund of wiſdom manifeſt in the works of God, and his admirable art and immenſe power, that I cannot ſince help thinking on them every moment. I thought I had already ſo accurately ſearched into the whole nature of Snails, that I could at length form many remarkable and certain obſervations, and from thence ſtrike out ſome general rules. But the further I advance in inveſtigating the wonderful works of

God, the more and more I find they all as far exceed the bounds of human ingenuity and underſtanding, as mortal man, who in reality is nothing, is from being able to diſcover fully the infinite and incomprehenſible perfections of God.

The water Snail, which I here exhibit, Tab. IX. fig. v. *a*, naked, without a ſhelly covering, is found in great quantity in the ditches of Holland, and in large freſh-water rivers; it lies moſt commonly in the ſandy fords or ſhallows of the latter, or where there are any ſtones. It creeps in ditches near and among the water plants, and in mud, which it takes as food; and alſo in white clay, in which I firſt found it. Hence it becomes dirty, and is often ſo covered with a cruſt of filth, that all the beauty of its ſkin or covering is almoſt loſt. I have therefore broke off the ſhell from the body of the creature, and only repreſented the Snail without it. But becauſe the ſhell has alſo a ſingular and remarkable ornament, and exhibits ſomething truly worthy of obſervation, I ſhall afterwards delineate it in the manner it was found, whole, and without any imperfection in the uterus, and appeared under the microſcope. Though I have found in rivers ſome of this kind of Snails, which were leſs than thoſe which I exhibit in the figure, and had little dirt upon them, yet I never was ſo happy as to ſee the beauty of their ſhell wholly free of filth.

The things that demand notice on the outſide of this Snail, are the head, Tab. IX. fig. v. *b*, its horns *cc*, the eyes *dd*, the aperture of the uterus, the branchiæ or gills *f*, the verge *g*, the convolution or winding of the body *h*; and laſtly, the verge, which ſerves as a foot *iii*, whereon is placed the operculum or cover of the ſhell *k*. The head *b* is diſtinguiſhed from the heads of all other Snails, becauſe it is ſtretched more out of the body, and is more viſible; nor is it at any time drawn back to the inſide, but only ſhortened a little by the wrinkles of the ſkin. In the fore part is ſeen a ſmall aperture, which is the mouth; the horns *cc* are ſharp at their extremities; and at their root or baſis, where they ſpring on each ſide of the head out of the body, are fixed the eyes, which are placed ſomewhat higher than in other water Snails, and therefore agree in ſome degree with the eyes of ſhelly or teſtaceous animals. All theſe parts are very beautifully variegated with yellow ſpots on a black ground. On the right ſide of the uterus or vulva, is ſeen an extremity or edge, which the Snail ſometimes protends out of its ſhell under the verge. It is of a muſcular texture, and may therefore be expanded and contracted at the diſcretion of the Snail. This is the reaſon why I firſt took it for the aperture of the verge. Above the head are ſeen five appendages under the verge, which, I think, are the branchiæ or gills. The verge very nearly approaches to that of other Snails; but it has not ſuch a ſtrong and remarkable motion, though it is of a tougher, more firm, and more tenacious texture. The convolution of the body is the ſame as in other Snails.

The verge, or loweſt part of the body, whereby the Snail creeps, is more worthy of notice; for the operculum or cover is annexed to it. This operculum is neither bone nor ſtone, but approaches rather to the nature of claws or talons; it is therefore in the purple Fiſh kind, called the unguis or claw, and the unguis adoratus; becauſe when burnt it ſmells like caſtor or beaver, and is uſeful in the ſuffocation of the womb, or fits of the mother. If the operculum or cover of the Snail whereof we here ſpeak, be burnt, it has no diſagreeable ſmell. Its ſtructure is elegant: it conſiſts, as it were, of many rings, ſomewhat round, and differing among themſelves principally in the brightneſs or obſcurity of their colour. On the inſide it is hollow like a ſhell: the tail of the body, annexed to this cover, is fixed thereto with ſtrong muſcles; by the help of which the operculum or cover may be bent, folded, nay, complicated towards the mouth and horns, when the Snail betakes itſelf to its ſhell; and by means of this, as it were, little door or entrance, which it carries about it, it ſecurely hides itſelf in its ſhell, ſafe from all common dangers. This the Snail does as ſoon as it perceives the leaſt unuſual motion in the water, for I never knew a more timorous creature than this. It naturally creeps very ſlowly, and ſwims in the water with its body oppoſite to the ſurface of the air, as I have before related of the common water Snail.

Theſe are the external parts of this Snail; but the internal parts that we have obſerved in it are indeed ſo many miracles, ſo many ſtrange and unheard of things, as probably never, hitherto, came into the mind of any perſon. I therefore invite and require all atheiſts, who do not ſcruple to aſſign the generation of ſmall animals to accident or chance, to this ſplendid entertainment, that they may learn to give the praiſe and glory to God alone.

When one attempts a diſſection of this Snail, it immediately draws itſelf ſo much back into its ſhell, and preſſes its operculum or cover down ſo cloſely, that one cannot put the point of a little needle into it. You muſt therefore break open the ſhell, which is very firm, with a flat forceps, and take the Snail out with your hands. Then it will be obſerved that its muſcles are ſtrongly inſerted in its ſhell, and principally in the foremoſt or anterior part of it. Whilſt this Snail lives, its diſſection can ſcarcely be performed, ſince it bends or winds its operculum or cover, Tab. IX. fig. VI. *aa*, againſt the fore parts of the body in ſuch a manner, that the former is doubly folded; beſides, both the mouth and horns *b* are in ſome meaſure drawn in.

The diſſection ought to begin next to the vulva *c*, and the verge ſhould be opened there with a little pair of ſciſſors; after which four different parts come at once in ſight; theſe are a ſmall margin very beautifully folded *d:* the end of the inteſtinum rectum, or ſtraight gut *e*; then the branchiæ or gills *f*, ſome of which appear out of the verge in the former figure: and at length the uterus *g*, which I have here delineated as diſſected and opened together with the living fœtus contained in it; for the young are brought forth alive by this Snail.

The verge has not a ſingular or remarkable aperture as in the other land and water Snails, but the whole is almoſt open on every ſide: the Snail however knows how to move the muſcular parts of the verge, and to ſwell them out of the ſhell in ſuch a manner, that by this means it draws the air into its cavity; and this air is afterwards expelled from thence again, when the Snail hides itſelf in its ſhell. Thus may this ſmall complicated margin be very eaſily ſeen; the doublings or winding plaits or wrinkles of it ariſe, in my opinion, from the bending and contraction of the body. If this little part *d* be diſſected, it appears to be only a congeries or heap of tranſparent, chryſtalline, and equal globules, which are of a ſtony nature, and make a craſhing noiſe under the diſſecting knife. The horns, the upper ſurface of the mouth, and many other parts of this creature become petrified, and therefore alſo make a noiſe like ſand, when they are chewed a little in the mouth. I mixed ſpirit of vitriol with them, and it cauſed a very ſtrong fermentation.

This firſt obſervation is, therefore, very ſingular, and merits particular conſideration. We ſee how the omnipotent God could frame a little being, which conſiſts, as it were, of ſmall ſtones, and yet can move, agitate, contract, draw in and extend theſe its parts; becauſe muſcles and their tendons are inſerted in and run through them. But who can deſcribe how the veins, arteries, and nerves are there interwoven and diſpoſed? Nobody truly, but He alone who made all theſe things. That congeries of chryſtalline globules, in particular, which is ſo copious in the horns, that one can hardly find a place wherein the parts aforeſaid may not be conceived to be ſituated; ſo that even from thence it appears clearer than the light at noon day, what exquiſite arts and unheard-of miracles the moſt ſagacious Architect has hidden in the immenſe volumes of his works.

If the inteſtinum rectum or ſtraight gut *e* in this Snail be opened, it is uſually found to be full of an earthy gray ſubſtance, and divided on the inſide by many membranous and nervous partitions or incloſures like little valves, and grows larger and larger continually, until at length it paſſes the liver and ſmall guts, and ends in the ſtomach, which ſeems to be like a ſmall tube or pipe. The excrements which this Snail throws out, are a congeries of oval particles, linked or joined together, ſuch as are found in the inteſtines themſelves.

The parts which I call the branchiæ or gills, Tab. IX. fig. v. and vi. *f*, are likewiſe very wonderful; they are diſpoſed in a neat order, they are of equal length, and are placed at the ſides of the inteſtinum rectum or ſtraight gut, which they accompany for a great way into the inflexion of the body. If you view them with the aſſiſtance of glaſſes, they reſemble a comb with broad teeth, though in ſoftneſs and delicacy they are like little membranes. At firſt I thought that theſe little parts were membranous expanſions of the uterus; but from their ſituation and ſtructure I afterwards found that they agreed more with branchiæ or gills.

The uterus, which, as we have ſaid, is repreſented, fig. vi. *g*, open here, is ſituated in this Snail where the ſtraight gut is ſeen in the common covered Snail. When I opened it gently, I immediately met under its upper coat, which it has in common with the coat of the verge, a congeries of oblong little parts, fig. vii. *a*, which were very numerous, and differed ſomewhat in their length, figure, and thickneſs; and when I removed them from their places, I found they were all alive, and were ſo many living little Worms, as there appeared particles of that ſort. On the inſide of theſe Worms was ſeen an oblong tranſparent aſh-gray coloured furrow or ridge. When I began to diſſect one of theſe Worms, two, nay three, and ſometimes four incloſed Worms of the ſame kind iſſued forth *; having almoſt the ſame figure, that is, a thick head, fig. viii. *a*, and ſmall tail *b*, like young Frogs or Tadpoles. The former Worms indeed moved ſomewhat ſlowly, but the latter being put into water, ſwam very ſwiftly, and very ſtrongly twiſted about their little tails. I muſt confeſs the ſight of theſe aſtoniſhed me, as I never expected to have met ſuch, and ſo many miracles in one little creature, or that I ſhould have been ſo well convinced of my own ignorance and blindneſs in a ſingle ſubject.

All theſe Worms exhibited a roundiſh little part, tranſparent through the middle of their body; but at the tail appeared ſome ſoft little points almoſt like hairs. I could not find any excrements in them. The little creature itſelf, viewed in the ſun with a microſcope, ſeemed to conſiſt entirely of ſmall grains of ſand. When I had afterwards taken all theſe parts from their places, a new miracle preſented itſelf to me: I obſerved that the whole tube of the uterus likewiſe conſiſted of chryſtalline little ſtones, which were as numerous and as thick and cloſe together, and diſpoſed in the like order as I have before related they were about the ſkin, the complicated margin and horns. Hence I really think that this little creature may be properly compared to the coralline cruſt which ſurrounds hard coral; for the ſkin which covers the branches of corals, is almoſt of the ſame ſtructure, and may likewiſe be eaſily ſeparated from the hard coralline ſubſtance underneath. Nay, the ends or tops of coral are alſo of the ſame ſoftneſs; and I have found them ſtill tender after the coral had been out of the water ſome months: this I have before obſerved in the letters that I wrote on coral. In the common water Snail I likewiſe ſaw here and there ſome little round chryſtalline parts, which I think were likewiſe globules of ſand of the ſame nature. In the ſtraight gut of that Worm, out of which iſſues the Gad-fly, I obſerved ſomething like this, as I ſhall deſcribe and repreſent when I come to its hiſtory.

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* The Eels in paſte are in this manner viviparous, and there does not appear to be any diſtinction of ſex in reſpect of the produce, for all are bearers. The late Mr. Sherwood has given an account of this to the Royal Society, the truth of which I know, having made the experiments with him.

When I afterwards opened the uterus, I was more aſtoniſhed: I found a ſmall Snail in it [*], in every reſpect perfect, which had already broke out of its membranes, and ſhewed the ſame diſpoſition and the ſame manners with the larger one its parent. Thus I learned that this little creature brought forth young Snails alive, as big as common peaſe, Tab. IX. fig. ix. *a*, which had their ſhells and coverings pretty hard; and that they were likewiſe complete and perfect in all their parts.

This ſhell, fig. x. *b*, afforded ſo beautiful an appearance under the microſcope, that nothing like it can be imagined. It was twiſted into four ſpiral parts, whereof the innermoſt diminiſhed its windings by degrees, until it ended in a pretty blunt point, almoſt reſembling a top. Moreover, the coat was covered with a perioſteum, and was very elegantly and neatly adorned with ſeven rows of briſtly hairs *c*, *&c.* Some black ſpots were here and there likewiſe ſeen, which were produced from the tranſparent body on the inſide. It was further divided by many ſpotted or ſpeckled little lines and other furrows; and alſo by little ribs that were notched and full of filaments; all which I have not delineated, leſt the figure ſhould have grown too big: nor have I leiſure enough at this time to enter upon ſo many things.

Theſe things convince me moſt clearly, that the ſhell or ſtony covering of the body is the Snail's real ſkin; ſince it has, even in the uterus, not only its own proper coat, but its hair. We are taught from thence alſo, beyond contradiction, that all theſe hard ſubſtances are nouriſhed and ſuſtained as well as the Snail's ſofter parts. For which reaſon the ſtony chryſtalline little grains before deſcribed, are fewer and ſmaller in the young and tender Snail than in the more grown one.

I find this ſhell, together with its animalcule, free and diſengaged on every ſide in the uterus, and not involved or rolled in ſuch coats as form the ſecundines. Hence one might, in ſome meaſure doubt whether this part, which I call the uterus, were not rather the œſophagus, and that therefore this animal had been only devoured by the Snail. But when I diſſected another Snail, I found twelve perfect eggs therein, ſticking in the uterus; each of which had its little navel-ſtring; Tab. IX. fig. xi. *aa*, and ſome of them had two *bb*. The ſtrings were ſomewhat broader near the egg, but where they were connected with the uterus, they were like a ſmall filament. They adhered almoſt in the middle of the uterus to a ſmall ſeam or ſuture.

The ſix firſt eggs, which are placed in the fore part, each contained a Snail, however ſmall, with its ſhell and food; the little body of this Snail lay extended out of the ſhell among the alimentary ſubſtance. The firſt egg had a larger Snail, but the ſecond, third, fourth and fifth a ſmaller. In the ſixth I only ſaw a ſmall point, the ſhell whereof was not yet conſpicuous.

In the other ſix little eggs, which were ſomewhat ſmaller than theſe, there was nothing to be ſeen, becauſe their tenderneſs made them tranſparent, and they were of one colour. On opening, them I found that there was a more tenacious liquor contained in them than in the former.

The ſix foremoſt eggs were as big as common peaſe, and were inveſted with a very tender and fine chorion and amnion, through which one might ſee the Snail within *ccc* languidly moving itſelf. Moreover, the whole amnion was filled with the moiſture beforementioned, which is the creature's true nouriſhment; and the Snail likewiſe ſwam in the amnion, as the human fœtus does in the mother's womb. As the Snail grows bigger, this humour is diminiſhed in proportion.

When I had broken the membrane of an egg which contained one of the ſmalleſt Snails, I found that the creature taken from thence, Tab. IX. fig. ii. *d*, was as big as the head of a common pin; but it did not move out of, nor go into its ſhell: for its muſcles were yet too tender, and ſome of its parts had been probably broken off.

If this egg was raiſed or lifted up by its ſtring, the Snail within remained in its ſituation without motion; but when the egg, which lay out of the uterus for one, two, or three days, was thus kept ſuſpended by its ſtring, then the Snail within fell to the bottom of the membrane *e* which conſtituted the egg. Hence one may conclude with certainty, that the cluſter of veſſels was broken on the inſide, though it could not be ſeen, becauſe all things are here limpid, white, and very tender. The humour or fluid itſelf, that is, the nutritious juice wherein the Snail ſwims, is limpid, though it ſtill approaches ſomewhat to the colour of whey, and when put into the water it becomes more thick or muddy; but if it has remained in the water ſome days, then it expands itſelf like glue, and at length it becomes clearer by the addition of the imbibed water.

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[*] Our countryman Dr. Liſter has diſtinguiſhed himſelf on the ſubject of this viviparous Snail. His obſervations in general agree with thoſe of this author, for truth is the ſame in whatever language it is written.

When I placed this little Snail under the microſcope *d*, I ſaw its eyes very black like pitch, fig. XII. *aa*, but the reſt of its body was colourleſs, or for the moſt part white; the horns *b* are ſomewhat blunt, the mouth *c* is open, all the reſt of the body *d* is ſtretched out of the ſhell; I found the operculum or cover *e* annexed to the hinder part of its tail, but the ſhell *f* was adorned with the like elegant apparatus and hair as I have repreſented in the tenth figure.

From hence, therefore, it is very evident in what manner this Snail, together with its ſhell or ſtony cover, is likewiſe by degrees increaſed, augmented, and become larger in the uterus. This obſervation is indeed of ſuch importance, that no body can deſire any more worthy of notice. Whoever reads theſe things muſt be obliged to confeſs, that the power of the Almighty cannot be known, by clearer and more convincing proofs, in any part of his works, than in thoſe minute animalcules, wherein that great Architect has incloſed and hidden ſo many wonderful parts, and ſhewn ſuch exquiſite art, that exceeds all human induſtry; ſo that one may employ his whole life in the diſſection of the ſmalleſt of all animals. For this reaſon I look upon the whole of my deſcription to be like a delineation of the ſun, defaced with coarſe materials; and therefore it is no wonder that the wiſe men of the heathens, when they had ſeen ſome miracles concerning the nature of women, cried out, "O! Being of beings, have mercy on me."

I have not accurately inveſtigated the remaining parts of the Snail, becauſe I only diſſected two pretty large ones, and a ſmaller one of this ſpecies, and becauſe it happened only by chance, that I began this wonderful diſſection, which deſerves more than any other to be completely perfected; great numbers of theſe Snails may be found at any time. I ſhall for the preſent briefly relate what more I ſaw of them.

I have obſerved that this Snail has no teeth, but inſtead thereof it has a proboſcis, trunk, or little tongue, by the help of which it ſeems to take its food in as by ſuction, as is the caſe in butterflies, and ſome kind of beetles. This little tongue is ſo elegantly formed, that it can ſcarce be exactly deſcribed, and as difficultly be repreſented in a figure; in the forepart it is of a bright or pellucid red colour, ſurrounded on each ſide with many ſmall parts, like the branchiæ or gills of fiſh, or like a comb with a double row of teeth. Theſe little parts grow paler towards the hinder ſide, and are of a horny ſubſtance, ſuch as the little tongue has in its diviſions.

The gullet is like a ſmall filament. I have not diſtinctly ſeen the ſtomach, becauſe I had broken ſome of the parts, but the part I took for the ſtomach was like a membranous little inteſtine.

The ovary is in every reſpect like that of hens, only that its eggs are not ſo large: I took theſe eggs in the beginning for a congeries or heap of chryſtalline globules; but when I had dried them upon glaſs they contracted, which is not a property of the chryſtalline granules of this little animal; I found them alſo ſoft in handling and biting them. I have nothing to ſay with certainty of the penis, though I ſaw ſomething like one.

The liver conſiſts of diſtinct viſible glandules, ſomewhat like pears, and I confeſs that the glandules of the liver never appeared plainer to me in any animal. As to the other parts of the abdomen, I have not yet either ſeen or examined them. The brain and nerves are conſtructed in a very different manner from thoſe of all other Snails that I have hitherto ſearched into; neither have I inveſtigated the eyes, ſince, with reſpect to theſe, this little animal agrees in ſome meaſure with cruſtaceous animals, as Crabs and Lobſters: hence I thought I ſhould have found ſomething in it, like the eyes of the Hermit Crab, which I obſerved to be like thoſe of Bees. The cornea tunica of the eye was in this alſo divided into little ſquares.

I have not been able yet to diſcover how this egg comes out of the ovary into the uterus, for the bottom of the latter ſeems to be ſhut up; but whether there be a tube in it there, as in Frogs and Tortoiſes, I am hitherto ignorant; I am at as great a loſs to know what time the egg afterwards remains in the uterus, before the little creature is diſcloſed from thence as a perfect Snail. If we conſider the remarkable ſize of the ſhell, we may reaſonably conclude that the egg lies there a long time. Hence I ſhould think that ſuch ſmall Snails and eggs may be found in the uterus at any time of the year. As to the Snails themſelves, I now know how to get a great number of them, nor will it be difficult to exhibit their fœtus.

Who can explain after what manner this egg is fecundated? or how life and motion are communicated to all its parts? ſo that, like a clock, having been produced with all its wheels or limbs by its parent only, and having life and motion from the male ſperm, it continues ſtrong and vigorous, until its little chain be unwound: ſo we may term the death of all thoſe who have life and breath. Theſe things are known only to that moſt ſagacious Being, who has numbered and meaſured the chryſtalline globules, the hairs of the ſhell, and all the parts of this little creature's body, nay of all animals, and who has given life and motion to every thing.

On the twelfth of March, in the next year after I began theſe obſervations on the viviparous Snail, I collected a great number of this kind, which I put into a large baſon full of rain water, and fed for a long time by the help of ſome potters earth diſſolved in the water. On the thirteenth of the ſame month I opened one of theſe Snails, when I found nine living Snails in its uterus, each incloſed in its proper membrane; though the humour of the amnion was almoſt conſumed, which I looked upon as a certain ſign, that their birth was near at hand. The larger of theſe fœtus's were placed foremoſt in the uterus, and the leſs next in order. When I had afterwards cut them out of the uterus, and put them into freſh water, I found they lived to the eighteenth of March, moving themſelves, and ſwimming like Snails more grown; nay, their manner of ſwimming was much more beautiful; but as I then had other matters to attend, I poured them and the water out together, nor have I ſince obſerved any thing further in them. The largeſt of theſe Snails were ſomewhat leſs than thoſe that are repreſented in Tab. IX. fig. IX. and the reſt were ſtill leſs in proportion.

On the twenty-firſt of March I opened another Snail of that kind, in which I found forty-four larger, and ſome very ſmall fœtus's, each incloſed in its membrane, and placed in a regular order in the uterus: ſome days after this I diſſected three others, in one of which I reckoned ſixty-five Snails, in the ſecond ſixty-ſeven, and in the laſt ſeventy-four, the ſmalleſt of theſe young Snails were not bigger than the point of a little needle. When I afterwards viewed them in a dark place by candle light, I obſerved that they ſwiftly and very beautifully moved and twiſted themſelves round in the humour or liquor of the amnion. But I found no eggs in the uterus of theſe laſt; hence I learned that theſe fœtus's were arrived to their full perfection, and afterwards only increaſed, that they might in ſome months after be in a condition to be brought forth by degrees, and by this means give way to new eggs to be again received into the uterus at that time.

Wherefore at whatever time of the year, you open theſe Snails, you will always find them pregnant, either with eggs or living Snails, or with both together.

On the twenty third of March I obſerved that ſome of theſe Snails, which I kept in a larger veſſel filled with water, had brought forth ſeveral young Snails of equal ſize or bigneſs. In ſome days afterwards I again ſaw that other young ones were brought forth; ſo that by this means, and ſundry obſervations, I learned by very certain experiments, that theſe Snails continually bring forth throughout the whole year. When in the month of June I opened ſome of thoſe that had brought forth, I found many rudiments of eggs in them, and ſome eggs of the ſecond degree, which were already ſo perfect, that the fœtus might be diſcovered in them; nay further, ſome eggs were ſtill more perfect; they lay in the uterus, and the young of them were to be produced ſoon.

In the month of June almoſt all my Snails died, becauſe I neglected to give them freſh water, and therefore in order to preſerve them for ſome time, I put them into ſpirit of wine among others which had periſhed ſome weeks before. I afterwards ſhewed above ſixty young Snails, in the uterus of one of theſe to Dr. Huygens, who, on his return to Paris, honoured me with a viſit; at which ſight he was greatly aſtoniſhed, and highly admired the ſtupendous and impenetrable ſecrets of nature.

On the twenty-fourth of July I weighed one of theſe viviparous living Snails that was freſh taken, and it weighed five drachms; in its uterus I found many eggs, in moſt of which was to be ſeen a moveable whitiſh ſpot or point, but in the reſt of them Snails of a larger ſize were obſerved, ſo that all the larger Snails were then already hatched. Then I began to clear the ſhell of this Snail of its dirty cruſt, and I found the perioſteum underneath unhurt. Its colour was then yellow mixed with green, and it was variegated with light red furrows and ridges; when the perioſteum was pulled off, the ſhell appeared white, and the ribs or ridges appeared of a purpliſh red. I have delineated a ſhell of this kind in its natural bigneſs, in Tab. IX. fig. XIII, where the ſtructure, windings, fibres, and aperture of the pillar may be clearly and diſtinctly ſeen in it.

Of that ſpecies of the Sea Snail, called by the Hollanders Aliekruyk.

THough many ſpecies of ſhell-fiſh, of the Snail kind, are found in Holland, I do not know that any of them are eat, except only this ſea kind, which is of the genus of the Turbo, and is called Aliekruyk; nor do we eat them at all times of the year, but only between Eaſter and Pentecoſt, and a few days after. At this ſeaſon, hogſheads of theſe Snails are carried into cities, and, being firſt boiled with water and ſalt, are ſold out by meaſure. Seafaring perſons in particular, and thoſe who deſire to provoke thirſt by ſalt meat, eat theſe Snails, taking them out of the ſhell with a needle or little pin, and then they drink a large draught. For my part I do not like the taſte of them; nay, they ſeem to me to affect the palate with too much ſaltneſs, and a kind of rank flavour. The liver is the moſt ſavoury of all their parts; in the reſt they eat hard and tough, and are therefore uſed, as I have ſaid, rather for whetting the thirſt, than as food. Their entrails alſo are ſo full of dirt and ſand, that they craſh between the teeth.

Theſe ſhell-fiſh are found very numerous on the ſhelves or ſand banks near the ſea, where the muſcles are alſo found, and among the latter they are frequently ſold; but they have alſo peculiar and proper places, in the ſea, where they ſtick together in large heaps. I have ſometimes taken them from the piles of timber, on which they are often fixed in the ſea, and ſometimes I have pulled them from large willow ſtumps, which were formerly laid on the ſhore, to break the violence of the waves; between theſe ſtumps, and among ſtones, are ſometimes found many other rare water inſects, as the Pulmo Marinus, or Sea Lungs, the Urtica Marina, or Sea Nettle, a ſpecies of the Echinus, the Stella, or Star-fiſh, Tubuli, or Sea Worms, Aſelli Marini, Sea Wood-lice, and others. The maritime coaſt of Holland is the only place I know wherein one can make theſe uſeful obſervations, for all other coaſts in general are ſmooth and plain, or covered even with ſand.

That this ſhell fiſh may be better known, I ſhall firſt deſcribe its external, and then its internal parts. Among the external parts I reckon the ſhell, which is the ſtony ſkin of this Snail, as well as of all other inſects that inhabit ſhells, it is on the outſide inveſted with a perioſteum, which appears very beautiful in young ones, becauſe no part of the ſhell has been in them worn out or rubbed off. Underneath, where this Snail, Tab. IX. fig. XIV. *a*, creeps out of the mouth, the door or entrance of its ſhell, the latter is a little globular *b*, but it loſes this figure by degrees, after it is rolled five times, 1, 2, 3, 4, 5, and is terminated in a ſharp point. The external ſurface of this ſhell is rough and unequal, ſince from its mouth or entrance to its acute end, it is folded and curled with thirty-one little ribs or furrows, which appear like ſo many threads above the ſurface *c*. I have not met with this exact appearance in all of them, as it ſeems in many to be worn out and obliterated with age; for the older ones have poliſhed ſhells, and are divided, fig. XV. *d*, only by ſome rings or wreaths of divers forms and colours; unleſs theſe ſhells may probably belong rather to another particular ſpecies, which I think is moſt probable. As to the colour of the ſhells, it is a light red in the former ſpecies, but in the other it is mixed with green and aſh-gray. and ſometimes red, purple, blue, or whitiſh. The internal ſurface of the ſhell is all equal and ſmooth, it is of a dark brown in both ſpecies, ſomewhat inclinable to a bluiſh purple.

The ſhells of theſe Snails are frequently eaten through, by ſome of the largeſt Sea Worms *, as may be ſeen particularly in the upper or pointed extremity, for it is frequently found gnawed there in conſiderable holes, in ſuch a manner, that the whole figure of the ſhell is obliterated in that part; nay, I found from experience, that thoſe worms ſometimes perforate into the inward texture of the ſhell, and there form various crooked and oblong hollows, Tab. IX. fig. XV. *e*, which ſometimes penetrate into the cavity itſelf, ſo that the Snail is obliged to draw up the hinder parts of its body.

I have found ſeven ſuch Worms in one ſhell, the Snail whereof was ſtill living and unhurt. I here exhibit one of theſe Worms, fig. XVI. *a*, if this Worm be viewed with a microſcope, it is found to conſiſt of many annular inciſions, which are adorned, fig. XVII. *c c*, with ſmall hairs on each ſide; in the middle are ſeen two veins of a bloody colour, which extend their little branches on either ſide towards the interſections of the body. In the fore part of its head *a* are alſo ſome hairs, which are placed there like antennæ or horns: the like *b* are ſeen alſo at the tail. All theſe Worms had a very thin ſkin; they were of a tender conſtitution, and moved but very little. Whether this might have proceeded from my hurting them, by ſtriking them with a hammer, or was natural to them, I cannot ſay. In the foulneſs which adheres to Oyſters, I ſaw a ſpecies of larger worms, which were not in figure very unlike this ſmaller kind, and, like the Glow-worm, ſhined in the dark.

All theſe ſhell fiſh ſeem to be ſubject to this Worm as a diſeaſe, ſince few of them are met with, whoſe ſhells are entire and ſound at the end of their convolutions or windings; for the ſhells are always inveſted there with a dirty or filthy aſh coloured ſubſtance, wherewith they are more or leſs infected, and in which theſe worms ſeem by degrees to fix themſelves, ſo that at length they ſeize on the ſkin of the ſhell fiſh, as their proper habitation and food, though the Snail ſtill continues to live in it. This ſhell has very hard and ſolid joints, as appears in its ſpiral pillar, which is likewiſe very thick; hence it is that the Snail may be eaſily diſengaged from it, ſince the ſhell flies in pieces like a flint, if it be ſtruck ever ſo lightly with a hammer.

The body of the Snail, which creeps out of this ſhell, but is by its muſcles very ſtrongly annexed to the pillar of it; the head and mouth, Tab. IX. fig. XVIII. *a*, are nearly like the Snails, and ſo are the horns *b b*, and eyes *c c*. The colouring of the ſkin only differs, for it is variegated with black furrows and ſpots on a white ground: in regard however to the colour of the two ſpecies, there is ſome difference to be obſerved. Behind, at the verge of the body *dd*, is the Snail's operculum or cover *e*, which it ſuddenly draws in at pleaſure, and by this means ſhuts up its ſhell, when it meets with any thing unuſual: the creature provides for its ſafety in the ſame manner, when any thing is ſuddenly preſented to its eyes; ſo that I may venture to affirm from hence, that this is the only ſpecies of Snails that I know, wherein any manifeſt ſigns of ſight appear; though in the mean time the eyes of this ſnail do not, in reſpect to the parts which are common to the eyes of all Snails, differ any thing from thoſe of others. On the inſide, at the edge of the ſhell, is ſeen the verge, which ſurrounds the whole body, and is pervious to no air: this I have remarked alſo in other ſpecies of Snails. On the right ſide of it are two other apertures, one of which ſerves to evacuate the fœces, through the other the genitals are extended. And theſe are all the outward parts of this little creature. Moreover, this Snail is of a very ſtrong conſtitution, for it can live ten or twelve days in the open air out of the water. I have alſo obſerved, when I was ſometimes in the month of September in the town of Petten, where theſe Snails are found in great plenty, near the ſea piles or ſea marks; that they ſtuck quietly on the dry land, after the tide was out, and on its flowing, were again buried under the water; ſo that they may, on this account, be conſidered as real amphibious creatures. The ſhell *f* wherein I exhibit this Snail, belongs to the ſecond ſpecies, and ſhews its faſciæ or wreaths nearly worn out. The operculum or cover conſiſts of a flexible horny ſubſtance, fig. XIX. *g*, which is compoſed of filaments applied to each other, and rolled like the ſpiral convolutions of ſome ſhells.

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* This is a common accident to ſhell fiſh: not only worms gnaw the ſhells, but the large ſhell fiſh of ſome kinds have a kind of bony engine, with which they pierce the ſhells, to get at the creature for their food. When it was doubted, whether foſſil ſhells were real, or exuviæ of animals, or repreſentations of them, from the ſportings of nature, ſhells taken out of the earth thus pierced by Pholades, were produced, and the objections ceaſed.

I ſhall give but a brief deſcription of the internal parts, both becauſe I employed only half a day in examining them, and becauſe they do not differ much from the entrails of other Snails. To begin at the mouth, we muſt obſerve, that all the parts of the jaws and palate are in this Snail of a bloody or purple colour. In the middle of the mouth is ſeen the tongue, Tab. IX. fig. XX. *h*, included in a ſingular kind of cavity, the whole of which it ſeems may be extended together out of the body; in the reſpects of colour and ſtructure it does not differ much from the tongue, which I have delineated and deſcribed in the Sepia or Cuttle-fiſh; but it differs very much from the latter in this, that it is almoſt two inches long, and at the ſame time beautifully convoluted or twiſted *i* into ſpiral bendings, like a ſerpent cloſely rolled together, and is thus placed on the inſide in the body, ſo that it paſſes with the gullet under the brain. The brain is ſituated behind the ſeveral parts of the mouth and palate, over the tongue and gullet, and ſerves thoſe parts before deſcribed as a kind of pully, through which they are tranſmitted. The part of the tongue which is in the body is cartilaginous, and ſo artfully and beautifully formed, that I could not delineate it fully in ten days; for which reaſon I exhibit it only in its natural ſize. In the hinder extremity the tongue is of a ſofter texture, and there includes a white matter in its cavity, which, when expoſed to the air, dries away and vaniſhes, contrary to what happens in the upper part. The uſe of this tongue will be manifeſt to any perſon who inveſtigates it with more experiments.

On either ſide, near the tongue, are ſeen the ſalival ducts, which ariſe from whitiſh and branchy glandules, and reach to the jaws behind, under the proper parts of the mouth and palate; and immediately under the gullet, two glandulous white little parts likewiſe come in view, the uſe of which I do not know: under theſe, on each ſide, are ſeen nerves iſſuing out of the brain, of which the optic nerves are the moſt conſiderable. The eyes, for the uſe of which theſe are appropriated, have three ſuch humours as I have before deſcribed at large in other Snails; the only difference is, that where the eye adheres to the skin, it is ſurrounded with a kind of white narrow circle, which I have not indeed obſerved in other Snails.

The ſtomach likewiſe is provided in the ſame manner, as it is in the garden Snail, and when it has decreaſed into a ſmall inteſtine, it afterwards proceeds according to the convolutions of the ſhell, and by its ſpiral and pyramidal windings, ſurrounds the liver, which is of a dusky colour, ſomewhat approaching to that of musk. The liver conſiſts of pretty large viſible glandules, which ſeem to communicate one with another, in form of a ſhrub; as ſoon as this inteſtine has paſſed through the liver, and the whole circuit of the ſhell's convolutions, it forms the inteſtinum rectum, or ſtraight gut, wherein I have obſerved the excrements divided into quadrangular globules.

The heart with its auricle is ſituated toward the left ſide. All the blood veſſels are of a whitiſh colour, and reſemble a Spider's threads: this is a very great beauty in the inteſtines of this little creature. I could not ſee the ſacculus calcarius, or the calcarious bag, nor the chain-like little part. Nay, ſeveral of the genital parts could ſcarcely be diſtinguiſhed in this ſubject, for I began this diſſection and examination in the firſt ſpecies of theſe Snails, at the end of the year, that is in September. But the purple-bearing oblong little tube, together with ſome of the other entrails, were diſtinctly ſeen to be of a very elegant ſtructure; all which I muſt paſs over now, and ſhall reſume this diſſection at ſome other convenient time.

Of the ſmall water Turbo.

Some ſmall Turbines are commonly to be met with, Tab. X. fig. I. *a*, in the places where the wonderful Snail, laſt deſcribed, is found. Theſe ſeem to agree entirely in ſtructure and conſtitution with the viviparous Snail, nor do they obviouſly differ from it, only that their ſhells are ſomewhat longer. I have not yet found them of ſo large a ſize as I could wiſh, and as I have not them now alive, I cannot exhibit the figure of this creature, I therefore hope that the benevolent reader will be ſatisfied with the figure of its ſhell only.

Of the umbilicated marble Snail.

This little Snail, which is variegated in the manner of marble, inhabits the freſh-water rivers of Holland, and therein adheres to ſmall ſtones: I have found it in the Vecht, beyond Amſterdam. It is frequently found about pieces of brick-bats and tiles, or pot-ſherds, broken pieces whereof have been thrown into the water. In the fore part, where the ſhell gathers into a ſpiral form, fig. II. *a*, it reſembles an umbilicus or navel; then it bends or rolls round in an oval winding, and becomes more expanded *b*. It is of a green yellow colour, variegated with a reticulated black ground like marble. The Snail that lives within is very tender, and as it died before I had brought it home and opened it, I cannot ſay much concerning it, nor exhibit the figure of its body. I ſaw that it had two oblong and ſharp horns, and two black eyes. The ſtructure of its tongue is almoſt the ſame with that of the wonderful Snail. It had pretty ſtrong little inteſtines. Its body, which was contained within the extreme ſpiral part of its ſhell, was of an obtuſe figure; becauſe, probably, this ſhell was very thick, firm, and ſolid. To the lower part of the body adhered a calcarious operculum or cover, which had a kind of ſwelling or peculiar production where the muſcles were inſerted into it, ſo that it reſembles the ſhoulder-blade in the human ſkeleton. On the outſide it was twiſted ſpirally like the ſhell itſelf. On the inner part, where this Snail creeps out of its ſhell, the opening or entrance, which is formed like a creſcent, only was open, and over-againſt it I obſerved a certain greeniſh ſpot, which reſembled in ſubſtance the ſhell of mother-of-pearl, and was likewiſe of the figure of a creſcent. To this ſpot the operculum or cover applies itſelf, when the Snail creeps out of its ſhell.

The flattened Snail.

Since many ſpecies of Snails are found in the rivers of our part of Holland, I ſhall briefly deſcribe only one kind of the water race, which is to be found there very common, both in ſalt and freſh water, as alſo in paſture grounds and near the high-ways. Its body is gray or blackiſh. On or at the fore part of the head are obſerved two lips, Tab. X. fig. III. *a a*, joined together, under which is the Snail's mouth, formed in the ſame manner as it is in the common water Snail. Under the mouth there is to be obſerved a part of the body, which I call the verge or foot *b b*, becauſe it ſerves it to creep with. The Snail frequently expands this verge in ſuch a manner as to cover the lower part of its lips and mouth therewith. A little higher in the head are two black eyes *c c*, ſituated at the baſis *d d* of the horns. Theſe horns are very ſharp in the fore part, but broader behind, and the Snail can contract them in ſome degree, but it cannot abſolutely draw them back into the body.

When its body *e* is puſhed forward out of the ſhell, it is conſiderably long and ſlender. Near the ſhell is obſerved a part of the verge, which the creature can raiſe out of the water when it ſwims; ſo that by means thereof, it may draw the air into its body; the verge therefore has for this purpoſe a ſufficiently large aperture, Tab. X. fig. III. *f*, in which is ſeen the openings *g* deſigned for the organs of generation.

Its ſhell or hard skin is twiſted or rolled about in a wonderful manner, and on the left ſide it is ſmooth or flat *h h*. It is inveſted with a diſtinctly viſible perioſteum, and is divided by very ſmall inciſions, ribs and furrows. But if this ſhell was ſo ſoft as that it could be rolled out, an oblong tube might be made of it. On the right ſide it is concave or diverging as it were from itſelf, but on the inſide it is rolled into itſelf, fig. IV. *a*, and therefore leaves a ſmall aperture in the middle, which I call the cavity of the pillar.

This Snail is a kind of intermediate ſpecies between the common water and viviparous Snail, as will appear from its diſſection now to be exhibited. It is very difficult to diſſect it, for it cannot be killed without hurting it, and it will not admit of being diſſected alive. However, I do not doubt but I may be able to ſurmount this difficulty, by the invention of ſome proper apparatus for that purpoſe, which I the more ardently wiſh for, becauſe as ſoon as one begins to break open the ſhell of this Snail, it immediately diſcharges a purple fluid or humour, which diffuſes itſelf throughout the inſide; even through the viſcera. If you kill it in ſpirit of wine, it likewiſe expels this purple fluid out of its body; but when it dies naturally in a little water, it ſhews no purple, becauſe the colour then probably vaniſhes by the changing the diſpoſition of the parts. When this Snail is drowned in milk, in which however it will live for ſome time, it is notwithſtanding found that the purple humour does not remain in the veſſels appropriated to it by nature: and though I ſaw the heart beating, yet I never found this purple liquid in it or its auricle. Hence I am inclined to think, that this liquor is contained in a kind of ſacculus or bag, which I have ſeen in other Snails, but could not hitherto diſcover in this.

The ſhell being gradually and carefully broken off from the body, the diſſection ſhould commence from the aperture of the verge. It will then appear, that this Snail agrees greatly with the wonderful ſpecies; for the verge is likewiſe here provided with a ſimilar ſmall margin beautifully folded, and made in the ſame manner as in the Snail before-mentioned; for in its texture is likewſe found a very great number of ſuch chryſtalline globules, which craſh and make a noiſe under the inſtruments. On the other, that is on the right ſide of the verge, is alſo obſerved a congeries of ſuch Worms, as I have in like manner obſerved in the viviparous Snail; and if theſe Worms be diſſected, a great many ſmaller ones, with thick little heads iſſue from them, which will likewiſe ſwim with very great velocity, and they alſo are ſtronger in their life and motion, than thoſe which I have deſcribed in the account of the viviparous Snail.

Theſe Worms likewiſe creep with very great ſwiftneſs; firſt ſtretching their head forward, and then, with great force, drawing the reſt of the body after it. Their greateſt ſtrength is in their mouth, which may probably have a kind of feet, as I have ſeen in other little creatures, and ſhall hereafter deſcribe and exhibit in figures. Theſe Worms are much ſmaller in this than in the wonderful Snail. When I was certain of this fact of the Worms, from obſervation, I kept ſome thouſands of them in the water, wherein I kept theſe Snails encloſed in a large glaſs veſſel, and I ſaw that they moved ſwiftly. The little part of this Snail which contains theſe Worms in the upper part of its membrane, is on the inſide of a bright yellow colour; and, in my opinion, may probably be accounted analogous to the purple-bearing bag in other creatures of this kind; but this I ſhall not affirm certainly.

This Snail agrees with the common water Snails with reſpect to the external ſtructure of the mouth and teeth. It wants an operculum or cover, but as to moſt of the viſcera it is likewiſe like them. Its ſtomach is formed in the ſame manner as that of the Hen. The brain is ſituated alike, though there is ſome difference in the nerves. The heart is placed in the left ſide of the body. But there is one peculiar thing in this, which is, that the liver conſiſting of glandules, is not protended to the extreme cavity of the ſhell: I have found there a ſmall part which was filled or crammed as it were with myriads of the thick-headed little Worms before deſcribed. The chain-like little part follows next, behind which is placed another glandulous purple-coloured ſmall part, and after this again is ſeen another yellowiſh little part near the uterus, which is of the like ſtructure with that in the water Snail, and opens with three tubes into the hinder part of the neck. The penis is formed in the ſame manner as in the common water Snail, nor has it any thing peculiar in it, only that where it is extended out of the body, three ſmall folded parts are ſeen, the middle whereof is very beautiful, and is, in ſome meaſure like a muſhroom, ſupported by a ſmall foot, and divided on one ſide.

The ſmall flattened Snail.

This Snail is in moſt reſpects like the former, nor does it differ from it, except that its ſhell is on each ſide almoſt ſmooth, and is concave, and adorned with a ſmall kind of margin, Tab. X. fig. v. *a*, by the addition of which it happens that the furrows or little ribs in the ſurface of the ſhell are bent in a different manner. It is ſeldom found larger than it is here repreſented. There is alſo ſome ſlight difference in the external part of the body. The horns are fleſh-coloured, though the body itſelf is blackiſh. The ſhell of this Snail put in the ſun is almoſt all tranſparent, but particularly in its internal windings, which are on every ſide ſtained with purple. The punctum ſaliens, or beating heart, is obſerved to be deeply tinctured with the like colour. But if the body of this Snail, after it has crept out of the ſkin or ſhell, be pierced with a ſmall needle, and the needle afterwards extracted, it draws back its body very deep into the ſhell; and then it is obſerved, that a juice of a purple colour inſenſibly diſtils out of the wound. This I take to be a certain ſign that this little creature has purple blood. Whether this ſame thing holds in the foregoing Snail, is yet to be diſcovered as alſo in a ſmaller one; the ſhell of which is likewiſe probably ſo thin as to be tranſparent. This and the former Snail are found in the ditches in Holland, as well as near the highways and in paſture grounds.

Of freſh-water Muſcles, found in the rivers in Holland.

IN the river Vecht above Amſterdam, and in other rivers, is frequently found a ſpecies of Muſcles, which are indeed buried in the clay and mud next to the banks, but they lie free and diſengaged, and ſtretch out their ſharp-pointed part. When the bottoms of the Vecht or neighbouring ditches are cleaned, theſe muſcles are found in great numbers. I diſcovered three ſpecies of them; a larger ſort with thin and broad ſhells; a ſmaller more oblong, and with thicker ſhells; and a very large kind, which is of a ſomewhat different texture.

I only examined the middle ſpecies of theſe, that is, thoſe which are moſt common. Theſe do not open themſelves much, they only make the two wings or lips of their bodies to ſwell a little out of the ſhell, and by this means they can fill themſelves with the river water. Beſides, they emit out of the ſhell ſome ſmall ruddy apiculi, or ſmall points, with ſharp extremities; and, as thoſe are on the hinder part covered with a blackiſh ſubſtance, they reſemble ſo many ſharp and black little ſpines, made like the papillæ that are obſerved on the ſurface of a Cow's tongue.

I had intended to complete the whole anatomy of theſe Muſcles; but when I opened two of them, all the parts that I found in them were ſo ſtrange, and ſo much unknown to me, that I deſiſted from my purpoſe for that time. For, as I had never before accurately diſſected any ſpecies of Muſcles, I ſaw that it would have taken up a very long time to have finiſhed this buſineſs, and I was then deeply engaged in other matters. I therefore reſerve this work for a more proper opportunity. But I ſhall now briefly relate what appeared at firſt ſight to me on the inner and outſide of this Muſcle, and in its ſhell, and ſhall, in particular, explain ſome things concerning the inſertion of its muſcles; whereby the hiſtory of what I have before ſaid of the Muſcles being inſerted in the ſhells of the Snails, will be conſiderably illuſtrated.

When the ſhell of this little Muſcle is carefully broke in little pieces with a forceps, and ſeparated in the part where the Muſcles are inſerted, then offers itſelf to view in the creature, its lips, and with this the verge; theſe wind about the whole body, and cover it as it were with two wings or lips. One of theſe is obſerved to be, Tab. X. fig. VI. *a a*, bent back to the ſide of the body. On the lower ſide of it, and likewiſe on the other ſide of the body, are ſeen papillæ as before mentioned *b b*, tinged with a black colour, which may eaſily be wiped off with a bruſh. The papillæ ſeem to me to be the extremities of ſo many tubes or trunks, whereby the Muſcle draws into its body, ſmall particles of mud and ſlime, for the gullet ſeems to communicate with them. On each ſide of the body are four branchiæ or gills, each conſiſting of three membranes, the middle whereof is formed like a bull-ruſh mat, and is compoſed of longitudinal and tranſverſe filaments, and may be ſeen through both the external membranes. All theſe filaments ſeem to me to be tubes, through which the blood moves as it does in fiſh. The largeſt veſſels are ſituated in the lower part of the muſcle; and from thence ariſe, I think, thoſe tubes, which, whoever purſues them ſo far, will find pretty ſtrongly connected with the papillæ that draw in the food. On each ſide, the Muſcle Tab. X. fig. VI. *cccc* has four ſuch larger branchiæ or gills, and four other ſmaller ones, *d d d d*, placed towards the hinder part.

The body itſelf conſiſts of two parts, a hard *e* and ſoft *f*. Theſe I take to be the thorax and abdomen. The harder part is made up of a congeries of many muſcles, which run from one ſide of the body to the other, with ſtrata or layers of long fibres, and being then carried over the ſoft part towards the branchiæ or gills, and wings or lips, they afterwards give various muſcles underneath to the belly. The thorax riſes into a point, and is of a colour ſomewhat approaching to yellow. When opened it exhibits many muſcular fibres running tranſverſely from one ſide to the other, from which the thorax obtains its hardneſs and ſtrength. Under this is placed the brain covered, with a bright-yellow membrane; but the ſpinal marrow and nerves are white, and they are divided into branches which are detached in great numbers to the muſcles.

I find four different parts in the abdomen, a liver, fat, an aſhy-gray ſubſtance, and ſeveral membranous and muſcular expanſions. The part which I take to be the liver, is very large; it conſiſts of a congeries of ſmall oblong glandules, which are placed near the hepatic veſſels, and reſemble ſo many uvulæ reſting on their little ſupports. Its colour is a blueiſh red, and where the veſſel is thickeſt, a glutinous matter is contained in it. There is a great quantity of what I call fat in the abdomen; it is divided into ſmall glandulous little knots, and is of a bright white colour, ſo that one would take them for little eggs, only there is ſo great a quantity here, that it reaches even to the ſpinal marrow. Many membranous and muſcular expanſions are likewiſe ſeen in the belly, but whether they are interwoven with veſſels and nerves, or with muſcular fibres, I cannot exactly determine. To conclude, there is likewiſe a great quantity of aſh-coloured matter, diſtributed among the fat: we find the ſame ſubſtance depoſited round the larger veſſels of the branchiæ or gills, and in many other places.

I could not hitherto diſcover either a heart or a ſtomach in this creature, but ſhall reſerve both for further inquiries. The principal muſcles that ariſe from the back are here very ſtrong, and divided into many tendinous fibres, and are firmly inſerted in the ſkin or ſtony ſhell of the creature, ſo that by this means various holes and cavities are obſerved to be formed in the ſhell, becauſe ſome of the tendons are fixed in it deeper than in others. Out of the back ariſes, among others, a very beautiful ſmall muſcle, which paſſes through the ſhelly part that joins the two valves of the ſhell together, as through a pully, and is afterwards inſerted in the ſharp-pointed extremity of the ſhell: but the muſcles are not ſo ſtrong about the acute extremity as elſewhere. The ſame are likewiſe very ſhort, which is the reaſon that this Muſcle can open the valves of its ſhell but a little way; ſo that if you attempt to ſtretch them further, even with the leaſt force, they immediately break.

On the inſide of the ſhell are obſerved five particular parts, in which the muſcles of this creature are inſerted, that is in the fore part of the acute extremity, where the inſertion is indeed broad and formed into a circle, Tab. X. fig. VII. *a*, but not very ſtrong. The Muſcle is very ſtrong at the thick end of the ſhell, becauſe the muſcles are there very firmly united with the ſtony bone: but one may there ſee four little apertures *b* ſunk in the ſhell, wherein the tendons of the muſcles are united with the ſhell, or rather change into a ſhelly ſubſtance. The muſcles of the lips are inſerted, but not ſtrongly, almoſt in the whole circumference of the ſhell next to its extremity *ccc*. We obſerve that the ſpiral worm *d* of this ſhell ſwells ſomewhat beyond its arched cavity. There are alſo two eminences *ee*, by the help of which both valves of the Muſcle are very ſtrongly joined together as by ginglymus; which, together with the parts wherein the muſcles are inſerted, make a very beautiful appearance in ſome other ſpecies of Muſcles, and are wonderful in the larger ſhell-fiſh of this kind. This ſhell is on the inſide like that of mother-of-pearl. On the outſide it has various convoltions or little ribs, formed like creſcents, and is ſurrounded on every ſide with a ſtrong yellow-green membrane or perioſteum.

I have nothing more to ſay of this and the other creatures, as I only ſlightly made theſe particular experiments, that I might, as far as time would permit, illuſtrate the hiſtory of the covered Snail by the deſcription of ſome other kinds. I have examined into theſe things, that the reader, myſelf, and all mankind may learn to know God by his wonderful works, and adore and love him as the ſupreme Deity and the great Creator of nature. Doing this, we ſafely purſue the ſteps of Chriſt, in and by whom every thing we do muſt be acceptable to God: but if we do not follow or imitate him, we are like thoſe careleſs ſervants, who buried in the earth the talents committed to them, which God grant may not be our caſe; and may all perſons, according to their reſpective abilities, extol and praiſe him; for which end I have communicated theſe obſervations as my mite, and wiſh they may anſwer the intended purpoſe.

The method of cutting various images and figures in ſhells.

BEFORE I conclude the hiſtory of ſhell-fiſh, I ſhall firſt ſubjoin a method, whereby ſhells may be engraved and adorned with little pictures and figures, which is indeed a buſineſs of exquiſite art. Take yellow wax, and mix a little Venice turpentine with it, to make it more clammy, then add as much lamp-black with it as will make it very black. With this wax melted in a ſpoon, we may make any figures we think proper, on the ſurface of the ſhell, to be carved; then we cover thoſe parts that are left uncovered with wax, with aqua fortis, which may be conveniently done by the help of a ſkewer, with a ſmall piece of linen wrapt round it. If this be continued for a ſhort time, all the parts of the ſhell that are free from the wax will be eaten by the aqua-fortis, and in thoſe places covered with wax will be left an higher ſurface. And by this means the ſhell may be adorned with various figures, and apartments or diviſions, which appear to be externally made thereon. But if after the wax is ſcraped or taken off by melting it, any corners or uneven parts ſhould chance to remain, they muſt be planed and perfected with the inſtruments wherewith figures are engraved. Thus three, four, or five eminent figures may be executed one over another, according to the thickneſs of the ſhell, and the places which we would have elevated, are firſt covered with melted wax. But the place which the aqua fortis corrodes with its acrimony, ought to be waſhed with common rain water. Other corroding liquors are not ſo proper for this purpoſe as aqua fortis, becauſe they leave after them a ſandy ſubſtance like chalk, which produces a roughneſs that renders the appearance leſs agreeable.

The end of the hiſtory of SHELL-FISH.

A letter from John Swammerdam to the moſt illuſtrious Mr. Thevenot, on the anatomy of the Cancellus or Bernard L'Hermite.

ILLUSTRIOUS SIR,

WHEN I had the honour of your company for ſome days in Yſſi-ſtreet, it often happened that ſome miracles of nature excited us to admire the great Creator, who is aſtoniſhing in all his works. We have alſo debated on the ſame ſubject often, when you reſided in Holland, and I have ſhewed you various uncommon experiments on bees and other ſpecies of inſects. But ſince the ſecrets of nature have, by the many inſtruments and contrivances which I have invented, become clearer and more known to me; and ſince I can in one day inveſtigate what I have before ſpent a whole week on; I can therefore now add a great deal to the diſcoveries I formerly made. This you will be convinced of from the deſcription of the internal and external parts of the Hermit Crab, which I firſt obſerved ſome years ago at Scheveling. For, as Dr. John Oort, governor in Nyenrode, ſent me a large veſſel of theſe creatures, which, the better to preſerve them for ſome time, he had taken care to throw into ſpirit of wine immediately after they were caught: I cannot help giving you a full deſcription of what I obſerved in them, and what obligations I am under both to my old friend, the governor of Nyenrode, who is greatly delighted with the works of God, and to you, illuſtrious ſir, who keep me continually employed in theſe matters, and engage and perſuade me to ſearch into them. All mankind will admire the ſtupendous examples of the immenſe greatneſs of the wonderful works of God, which that ſupreme architect exhibits to our contemplation in the variety of the things which he has created, that we may acknowledge his wiſdom and infinite power in the works of nature, and be induced to love him moſt ardently, and above all things.

The fiſhermen who get their living in the ſea of Scheveling, take there ſeveral ſtrange creatures, as well in common nets as in drag nets, which they either throw again into the ſea, or leave on the ſhore, ſince they can get no profit by them. This is the reaſon that it is not yet known, how many and what wonderful creatures there are, to which the eternal power of God has aſſigned the ſalt waters as their habitation. I wiſh many more men had ſuch an ardent love for the ſciences, as you and the governor of Nyenrode, our friend, for thus the knowledge of natural ſcience, and the hidden cauſes in phyſicks would, by degrees, become known; and the incitements to our duty, by which we are ordered to love our Creator with all our heart, would be doubled. I am greatly obliged to you, becauſe when you were in Holland, you ordered many ſtrange creatures to be brought me from Egmont-ſtreet, which we afterwards examined with our common and dear friend Dr. Stenon. But I fear my long preface makes me troubleſome to you, by delaying the expoſition of what I promiſed, and the gratification of your eager curioſity. I ſhall therefore now relate to you in order, what I have obſerved in the ſpace of two days in the Hermits tranſmitted to me, and what ſtupendous things I ſaw in them.

The external parts of the Cancellus or Hermit.

IN the open veſſel wherein my Cancelli or Hermits were incloſed, I ſaw ſome of them had broken out of their ſhells, and that others ſtill lay in them. The ſhells of the largeſt were as big as a cheſnut, but thoſe of the ſmalleſt were not bigger than a large pea. The creatures themſelves who inhabit the inſide were large or ſmall, in proportion to the ſize of their ſhells. But all theſe ſhells were of the ſame figure, form, and habit, only that there was ſome ſmall, and, as it is called, accidental difference, in reſpect to the colour and lines. Some of the Hermits which ſtill lay in their ſhells, were diſengaged from the ſhell, ſo that they were affixed, by the ſtrength of their tail only, in the laſt ſpiral windings of it; but in others I ſaw very diſtinctly that in the middle of their body they were joined in the ſame manner to the ſhell itſelf *, and this is a property common to Muſcles and Snails. Hence, it appeared to me moſt certain, that the ſhell was as much the true skin of the Hermit as it is of the Snail.

Hence it ſeems matter of wonder that the learned Rondeletius ſhould write of the Cancellus or Hermit in this manner: “ Bernard “ L'Hermite ſe loge toujours dans les coquilles “ d'autrui, et qui'l n'en a point de propres;” that is, “ the Hermit always inhabits the ſhells “ of other creatures, nor has it any of its “ own.” I obſerve in the covered Snail, that by the help of its muſcles it is not only affixed to the ſhell, but even the tendons of thoſe Muſcles increaſed with the ſhell, and are actually transformed into it, in the ſame manner as the tendons of the feet of Cocks and Peacocks are inſenſibly oſſified through age. The ſame thing is alſo obſerved in the Hermit, for the tendons of its muſcles, firmly adhering to the ſpiral pillar of the ſhell, where the pillar forms its ſecond ſpiral winding, are obſerved to be all joined to that rocky ſubſtance. But as the tendons do not occupy a great ſpace with their inſertions; therefore the body of the dead Hermit quits them: and this was probably the reaſon that the great Rondeletius, following the doctrine of Ariſtotle, has not obſerved this matter. As all theſe ſhells have one and the ſame figure and ſtructure, it is manifeſt even from hence that they are proper to theſe creatures only, and are increaſed and augmented with them, as is the caſe in Snails and all other creatures that inhabit ſhells. I am therefore certain, that all Hermits which belong to the ſame ſpecies have likewiſe ſimilar ſhells; for I am taught by experience, that there are many ſpecies of Hermits that are not only very different from one another, but alſo live in different kinds of ſhells; this I have ſeen in my father's collection, and in many other muſeums.

The ſhell of the Hermit is moreover ſurrounded with a very thin perioſteum, and hence ariſes a new argument, which confirms, that the ſhell is the ſkin of this creature, which, with its perioſteum, covers it on the outſide. So that therefore the Hermits, as well as Beetles and cruſtaceous creatures, have their bones placed on the outſide round their fleſh, though there is ſtill ſome difference. This perioſteum is very thin, nor can it be better or more perfectly ſeparated, than by ſteeping the ſhell ſome days in lye, and rubbing it lightly with aqua fortis, for thus it parts from the ſhell. By this method the perioſteum may likewiſe be very eaſily ſeparated in ſome other ſhells. But it is ſo thick and remarkable in ſome kinds, that there is no need of this experiment. In other ſhells, again, which are rolled over rough ſtones, or that have been drawn through rocky and ſandy places with their inhabitants, this perioſteum is wholly worn off, and cannot therefore be then diſcovered in them.

Some of theſe ſhells were very ſmooth and beautifully coloured, Tab. XI. fig. 1. *a*, and glittered like a looking-glaſs. A ſpecies of the Fucus Marinus, riſing with ſmall points, covered the largeſt of them in ſuch a manner, that the whole figure of ſome were obſcured and hid, nor could the ſpiral windings of ſome of them be ſeen *b*. Moreover ſome holes appeared behind the points, and alſo ſome very ſingular little grains of ſand, ſome of which were likewiſe covered with the Fucus. Other holes were obſerved likewiſe full of ſofter purple coloured eminences. In ſome of the ſhells a ſoft ſea mud was found, in others a very hard one, the figure whereof was likewiſe ſpoiled by winding round the creatures. I likewiſe ſaw that a ſubſtance adhered to the internal ſurface of one ſhell in ſuch a manner, that there was no void ſpace either in the entrance or mouth in the fore part, or a little higher in the ſhell; only where the tendons of the muſcles were ſeparated from the ſubſtance of the ſhell. I obſerved further, that Worms had pierced the ſhells in ſome places, and how ſome of them had been broken and again joined together. Theſe ſhells are uſually moſt beautiful when the Hermits are ſmalleſt in them, for they are not then covered. In ſome other young ones of theſe, the perioſteum appears of a very remarkable figure and beauty, where the ſhells are not yet covered with the accreted matter; as I have obſerved in ſome ſmaller water Snails, in which the whole perioſteum was very delicately adorned with briſtly hairs. Let what has been hitherto ſaid of the ſkin of theſe creatures ſuffice. I ſhall now explain the other parts of the Hermit, and that they may be the more eaſily underſtood, I ſhall divide the creature into four parts, the head, thorax, abdomen and tail, and ſhall afterwards deſcribe every thing remarkable in each.

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* The ſolution of theſe problems remains for future obſervations. This author aſſerts, that the body of the Hermit grows to the ſhell; others affirm, that the creatures will at any time crawl out of the ſhell, on ſmoaking them with ſulphur: if ſo, the ſhell is no part of the creature.

In the upper part of the head are ſeen two eyes, Tab. XI. fig. 1. *c*, and on one ſide of the latter, two horns or antennæ *d d*. Underneath appear ſome articulated briſtly hairs, and alſo a mouth and teeth. The eyes are oblong, ſomewhat red, and in their aperture of a dark green colour: they are articulated on both ſides with the head, by the aſſiſtance of a certain dentated ring, which conſiſts of a like ſubſtance with the ſhell that ſurrounds the thorax and feet, and the other part of the eye is again articulated with the head. This upper part of the eye is likewiſe very hard underneath and in the middle, but it is ſoft above, where the cornea tunica is placed. The horns are compoſed each of three joints, whereof the largeſt are thoſe which are joined to the head on each ſide of the eyes; from theſe the horns inſenſibly grow very ſhort, and terminate as it were in ſmall briſtly hairs. In this thin and tender part of the horns I reckoned above one hundred and twenty very fine and delicate articulations, each of which was likewiſe adorned on each ſide with two pair of fine hairs. In the larger Crabs theſe articulations are very diſtinctly conſpicuous, and when the Crabs are boiled, the horns may be divided into as many plain and ſmooth rings as they have articulations of that kind. Between the firſt and ſecond joint of theſe horns of the Hermit, there is a ſmaller rigid or hard appendage, beautifully adorned with briſtly hairs.

Between the horns, under the eyes, appear a beautiful pair of rough hairs, which conſiſts of three joints, whereof the upper one is the broadeſt. Under theſe are ſeen the teeth, which are two little, hollow, white, oblong bones, and are furniſhed with ſtrong muſcles, wherewith they are moved. Between theſe teeth is placed an external bone, by which the creature takes its meat, for which purpoſe it has not only two arms or forceps *e*, *f*, but many articulated rough or briſtly hairs, of different ſtructures, which cover the mouth on the lower part. There are two very ſmall, ſmooth, broad, ruddy, ſhaggy briſtles, or rough hairs of this ſort, each of which has one joint only. There is afterwards another pair of larger briſtles of the ſame conſtruction, each of which has two joints. There is alſo a third pair, not ſmooth or broad; but with theſe, on either ſide, are two pair of ſuch little parts likewiſe articulated, and every hair of this third part in the ſame manner conſiſts alſo of two joints. The fourth pair is ſomewhat ſmooth and broad, and theſe are compoſed of three joints; to theſe are alſo joined another pair, each hair of which has two joints. There is in like manner a fifth pair, that are likewiſe double, that is, a larger one, compoſed of four joints; and the other, which is joined to the former, conſiſting of three. Laſtly, there are underneath, near the thorax, a very large pair of briſtly hairs, like two legs, each of which conſiſts of ſix joints, and has alſo on each ſide a ſmall part added to it with two articulations. So that computing the whole, there are here twelve pair of ſmall parts beautifully interwoven with briſtly hairs, which meet together when the Hermit ſwallows its meat, as is manifeſt from their ſtructure and ſituation.

The thorax underneath is divided in the middle as it were by two teſtaceous little bones, with which the two arms and the four fore legs, Tab. XI. fig. 1. *gg*, are articulated. And in order to ſee this diſtinctly, it is neceſſary to take the whole Hermit out of the ſhell, and to lay it on its back. Then four articulated briſtly hairs are ſeen between the eyes. fig. II. *aa*; but the other briſtly hairs before deſcribed cannot be ſeen diſtinctly, until after theſe are removed out of their places, becauſe they are covered by them. Near the eyes two horns *bb* come in ſight, and afterwards two arms are ſeen very diſtinctly, of which the left with its forceps *c*, is always leſs than the right *d*, though both are compoſed of five teſtaceous joints; to the uppermoſt of which is likewiſe joined by articulation a ſmall part, which may be called a thumb, and from this the forceps of this creature have their origination.

The four ſubſequent legs *e e* conſiſt of ſix joints, which are alſo like the arms adorned with prominent notches, briſtly hairs, ruddy ſpots and furrows. And further, with the thorax are joined two other pair of ſmaller parts like legs: and in the middle, between each pair of theſe, are obſerved ſome peculiar little bones, whereby theſe legs are joined to the thorax. The firſt pair of them, Tab. XI. fig. II. *ff*, has indeed five joints, and, in other reſpects, it is of the ſame ſtructure with the arms or forceps, and has, like them, a very ſmall thumb. The other pair likewiſe conſiſts of five joints, and is very worthy of notice *gg*, becauſe the firſt pair of theſe joints, that next to the thorax, or the fifth, if you compute from the extremities, is perforated with two ſmall tubes, iſſuing from the abdomen, through which the ſemen or eggs are ſecreted; which indeed deſerves very great conſideration. The upper part of the thorax, or back, is furniſhed with a ſmall ſhield; behind which is placed ſuch another, but leſs. On the ſides of the thorax the cruſtaceous covering of the back is thin, and if it be raiſed up, which may be done without diſſecting it, the branchiæ or gills are obſerved underneath, placed on each ſide of the thorax.

The abdomen is ſoft, and has no ſhelly or cruſtacious covering; ſince the ſhell itſelf is its coat, and does the office of that hard ſkin. The body is in this part bent near the duct of the ſpiral windings of the ſhell, with which it is ſurrounded. But this bending of the body is not ſo remarkable as in Snails; becauſe the body of the Hermit is not extended through all the turnings of the ſhell. The abdomen has on the right ſide three teſtaceous briſtles *hhh*, each of which conſiſts of two joints. Rondeletius, in his Hermit, ſeems to delineate ſix ſuch little parts, which are interwoven or planted with little eggs or ſpawn like beads.

Among many things worthy notice in the belly, what deſerves moſt particular conſideration is a certain eminent or prominent point *i*, which is naturally the firſt thing obſerved in the thorax, and is as the center, wherein all the tendons of the muſcles, and that part of the abdomen meet; and by the help of which, the Hermit is in that part fixed in his ſhell or ſtony ſkin, ſo that it can never go entirely out of it. Though its thorax, and the hinder part of the abdomen and the tail adhere to nothing, and that there is ſuch large room or ſpace in the ſhell, as that the Hermit can freely move itſelf therein; yet the thorax is forced to remain fixed in the ſhell, like the Tortoiſe in its houſe or ſhell.

The tail of the Hermit is alſo ſurrounded with a cruſt *k*. That this may appear the more plain, I have delineated it larger than it naturally is. This tail conſiſts of two teſtaceous articulations, Tab. XI. fig. III. *a*, to which are added at the end a verge as in Snails *b*, which forms the third joint, and ſerves to hide the fundament: for the inteſtinum rectum *c* terminates there in the ſecond joint. On each ſide of the tail are three pair of teſtaceous little bones *dd*; which, like the arms, are larger on one ſide than on the other, and beautifully decorated with ſmall hairs. The Hermit makes uſe of them when it finds an enemy approaching, to hide itſelf in the ſhell, or when it deſires to reſt; for then by their aſſiſtance it lies fixed in the hinder parts of the ſhell, or draws itſelf back into it. But if the Hermit draws to it, or contracts theſe little parts, it can then protrude its tail forward into the entrance of the ſhell, and thus it evacuates its excrements. For this purpoſe, I think, nature has given it ſo large a ſhell; the hinder windings whereof are not all filled with it, as we have before obſerved. The ſame is found in Snails that inhabit ſhells; which, for that reaſon, diſcharge their excrements through their neck, and have not a very moveable tail. Theſe little bones of the tail are formed, ſome larger than others, in proportion to the ſpace in the ſhell, for this is larger on one ſide than on the other. In the ſame artificial manner are built the wheels of french chariots made for aſcending.

The internal parts.

Receive, illuſtrious ſir, this brief deſcription of the external parts of the Hermit Fiſh, and permit me now to paſs to the internal, beginning with the abdomen, becauſe I have begun the diſſection there. When the abdomen is opened, the firſt thing that appears is the outer and inner ſkins, which are glandulous; and immediately under there is ſeen a fleſhy membrane. After theſe integuments are diſſected or taken off, a great number of whitiſh filaments preſent themſelves; which are delicately and orderly placed on very numerous and beautifully digeſted parts, in form reſembling inteſtines, fig. IV. *gg*. As I purſued the courſe of theſe white filaments to their origin, I ſaw they were blood veſſels, though of a white colour like a cob-web. What I firſt took to be the inteſtines were all appendages *, ſometime plain, and ſometimes divided; which were of a tubular ſtructure and whitiſh colour, and contained a matter ſeparated into diſſimular parts, and condenſed into a ſerum and coagulum. Theſe appendages were ſo numerous as to cover almoſt all the abdomen; but they were all connected by the blood veſſels, which I was obliged to break open with great attention, in order to diſcover their origin and beginning. Thus I at length diſcovered that theſe were on each ſide united, Tab. XI. fig. V. *hh*, into two common ducts, which grow near the ſtomach where the pylorus is placed, and are terminated in many unopened tubes *ii*. What uſe theſe appendages are of, and whether they ſerve inſtead of a pancreas, which is formed in that manner in many Fiſh, may be more accurately inveſtigated in the larger Crabs.

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* This is a conſtruction very frequent in the inteſtines of Fiſhes.

Among theſe appendages, at the bottom of the muſcles of the abdomen, appeared an inteſtine; which, without any winding, ran ſtrait from the ſtomach towards the tail; and whereof I have here delineated, fig. III. *e*, only a ſmall part, ſomewhat augmented beyond its natural ſize. It was full of gray excrements, which, when viewed with a microſcope, conſiſted almoſt entirely of ſmall chryſtals, which were regular grains of ſand. The ſtomach alſo contained partly the ſame ſubſtance, and partly ſome little fibrous membranes. Its upper part is placed near the back, its inferior in the thorax. It is in ſtructure partly membranous, and partly cruſtaceous: its bones are very beautiful. Above, below, and on each ſide, it has many muſcles, by which its parts are connected and moved. On the inſide, in the cavity of the ſtomach, I ſaw three diſtinct teeth, of a moderate ſize, each of which was divided into ſeveral ſmaller teeth: the teeth were of a pale lemon colour, but it was changed by degrees into a dark green, in that part where they terminated in little teeth or diviſions. Two other teeth-like little parts, which were uneven and notched, adhered alſo to the cavity of the ſtomach. This obſervation is certainly very worthy of notice, that the little creature, living like a Snail in the ſhell, is furniſhed with a double apparatus of teeth; for it has two teeth forward in the extremity of the mouth, and five others in its ſtomach.

Where the inteſtinum rectum or ſtraight gut begins, I ſaw the cæcum or blind gut moderately long, and beautifully twiſted, Tab. XI. fig. III. *f*, which I firſt took for the extreme appendage; but as I found it looſe and diſengaged in all the Hermits I diſſected, I therefore believe it is the cæcum. I ſhould not, however, venture to affirm this for certain, becauſe I have not diſtinctly ſeen its blind or imperforated extremity; for all its contents were coagulated and ſeparated by the ſpirit of wine, and the place wherein the inteſtine itſelf was ſeen, appeared ſo tranſparent, that I could not obſerve that particularity. Beſides, it was not like the appendages on account of its contents, nor was it inſerted in the middle, but ſomewhat on one ſide of the inteſtinum rectum.

In the abdomen, on each ſide of the appendages, there were two ſmall genital veſſels, fig. VI. *a a*, whereof that in the right ſide was the larger: both were, in many places, beautifully twiſted into ſpiral windings *b b*, and they proceeded thence curled, till they at laſt terminated in a narrow tube *c*. It appeared likewiſe how theſe, in their end, pierce or perforate the laſt pair of legs, fig. II. *g g*, in the middle of the fifth joint, which reſembles a bone or ſhell with a conſiderable tube, fig. VI. *d*. This I have delineated larger than it naturally is. This perforation appeared to me very plain, when I ſqueezed the contents through it, and ſeparated and unbound the tube itſelf. In it was a ſubſtance of a whitiſh colour, and when examined with a glaſs, it ſeemed all to conſiſt of very ſmall regular little parts, like round globules. I could not diſcern whether theſe were the rudiments of eggs, or the globules of a male's ſemen; ſince in all the ten that I diſſected, the ſame ſtructure was obſervable in the genital veſſels. The windings of theſe ſpermatic ducts were likewiſe connected by means of blood veſſels; and when I opened them, they were ten inches and an half long. Theſe are all the entrails that I ſaw in the abdomen; only that in the bottom of the belly were placed ſeveral muſcles, towards which the nerves iſſued from the ſpinal marrow. Part of the tendons of theſe muſcles terminated in the point, fig. II. *i*, above deſcribed; where the creature is fixed in its ſkin or ſhell, ſo that with their aſſiſtance, the Hermit may draw in and hide itſelf in the ſhell. Between the appendages I ſaw many little drops of fat floating, which reſembled the oil boiled out of the fat of Whales ſwimming in water.

If the thorax be opened above in the back, the firſt part that is there ſeen is the ſtomach, with its muſcles, which is of a remarkable ſize in this creature, and is really ſituated under the back, though I have, for method ſake, deſcribed it in treating of the abdomen. Behind this ſtomach, above the place where the inteſtine ariſes, is ſituated the heart, Tab. XI. fig. VIII. *a a*, which reſembles an irregular little piece of fleſh, and becomes ſomewhat pointed. It is of a ruddy colour there, but underneath and at the ſides it is white. I perceived four veſſels *b* iſſue from it above, and two *c* below; and one of the two lower ones was larger and thinner than the other; which however conſiſted interchangeably of ſomewhat thicker ſides, and ſent off ſome vaſcular ſprigs *d*. On the outſide of the ſurface of the heart I obſerved *b* ſeveral little holes; but on the inſide the heart was fibrous, and furniſhed with its pillars or columns like the human heart. I diſcovered only one venticle in this creature, as is the caſe in the generality of Fiſh; but I could not ſee its auricle. Moreover, I obſerved how the whitiſh veſſels in this heart, were diſtributed up and down through the body, eſpecially towards the branchiæ or gills, one of which I have repreſented magnified *e*.

There are here, as I have obſerved, eleven branchiæ or gills on each ſide of the body, ſo that they make twenty-two in all. They are ſituated at the ſides of the thorax, between theſe long cavities, which there form the articulations of the legs. They are of a pyramidal figure, riſing from a broad baſis *f*, and ending in a ſmall pointed top *g*. Each of them is, at the upper end, divided into two other parts, each of which conſiſts of a great number of ſmooth or plain lamellæ *h* or layers, which are applied cloſe to each other like the leaves of a book, and each of them is divided from the others very deeply, which makes indeed a very agreeable ſight. The ſtructure of the branchiæ or gills is partly cartilaginous and partly membranous; and their blood-veſſels are extended near the cartilages. Moreover the beginnings of the appendages are ſeen very beautifully in the thorax, as has been before obſerved.

After theſe little parts, together with the ſtomach, heart and inteſtines are removed, the ſpinal marrow preſents itſelf to view: it is placed entirely at the bottom of the thorax, and is not incloſed in a bone. It extends itſelf through the lower parts of the abdomen to the tail of the creature, and there terminates in the muſcles of that part. In order to deſcribe this matter the more exactly, it muſt be obſerved, that the brain, Tab. XI. fig. IX. *a a*, from which this marrow ariſes, is ſituated immediately under the articulations of the eyes in the head, which is very ſhort, and joined to the thorax. This brain is ſeen to be there divided into a right and left part. Above the brain appear the optic nerves *b b*, which are found to decuſſate over it, and to proceed towards the eyes, as I ſhall now ſhew. Underneath, out of the baſis of the brain, ariſe two ſtrong nerves *c*, which properly conſtitute the origin of the marrow in the thorax: theſe nerves are placed at a conſiderable diſtance from each other, in order to give a paſſage to the gullet, which is very ſhort, and reaches from the mouth to the ſtomach. The brain is therefore placed over the gullet, and the gullet again, as well as the ſtomach and inteſtine, are lodged upon the marrow in the thorax and abdomen. Theſe two originations of the marrow are again united a little below, and there form a remarkable ſwelling or knot *d*, out of which many nerves iſſue, which are diſtributed over the muſcular parts of the thorax as well as the brachia and legs. In men and quadrupeds ſuch cluſters are never ſeen in the body of the marrow, but always in the nerves after they have iſſued out of that part; but this is indeed the ſame thing in effect, for as the marrow itſelf is as it were a bundle of nerves, and is double in all ſpecies of animals, it is the ſame thing whether theſe cluſters are found in the marrow, which is a kind of thick and compound nerve, or in the nerves iſſuing from thence, which are the ſeparate portions of the marrow. Whoever accurately conſiders the marrow in man and other animals, will indeed moſt clearly obſerve this analogy; though Malpighius himſelf does not ſeem to have obſerved it, when he ſuppoſed there was ſo great a quantity of brains in the marrow of ſilk worms. After the marrow has formed this cluſter in the Hermit, it becomes ſimple again, though its two parts may, notwithſtanding, be palpably diſtinguiſhed; but theſe are ſo nearly applied and contiguous to each other, that they are as if they were but one. Afterwards is diſcovered another cluſter of marrow, and a third, fourth, fifth, nay, a ſixth, *e e e e e*; the nerves of this laſt are detached to the muſcles of the tail. The nerves which ariſe out of theſe little cluſters, are almoſt all beſtowed on the muſcles of the abdomen; whereas on the contrary, thoſe that iſſue from, the marrow itſelf, Tab. XI. fig. IX. *ff*, are likewiſe diſtributed to the viſcera. It is likewiſe worthy of notice after what manner the nerves decuſſate one over another, which I demonſtrate in thoſe nerves which iſſue before the laſt cluſter out of the marrow *g*, and are detached to the muſcles of the abdomen.

After the optic nerves have iſſued from the brain, they are incloſed in the annular *h* cruſt of the eye, and being again conſiderably expanded in the latter, they thus proceed to the verge of the cornea tunica, and there terminate like ſpheres, or in globular forms. No humours appear any where in the whole eye, like thoſe found in the eyes of men, quadrupedes, birds, and terreſtrial or water Snails; but it is obſerved to be of a texture entirely different, which is very worthy of attention. If the cornea *i* be taken from the eye, there is immediately ſeen under it a kind of limpid matter, fig. X. *k*, which is the colour of jelly, and is divided in a very elegant and regular manner. What part this is, and whether it has its origin from ſpirit of wine, I cannot exactly determine, as I never ſaw any thing like it in any inſects, whoſe eyes are of the ſame ſtructure. I ſhall therefore at a proper time examine this little body, in the larger Crabs diſſected alive.

But before I proceed further, it is to be known, that the cornea tunica is divided like a net, in the ſame manner as in the eyes of inſects, but theſe reticulated diviſions are here much deeper. I find every diviſion to be hexagonal, as well in this Hermit as in inſects. Moreover, all theſe diviſions wind themſelves above in a ſpherical figure, which however is not here very remarkable, ſince the ariolæ or little beds of the diviſions, are very ſmall and ſmooth. On the inſide, in the hexagonal cavities of the diviſions of the cornea, was fixed the glutinous matter before deſcribed, which was there divided in the ſame manner as the cornea itſelf. Under the latter appeared a great number of little fibres, fig. IX. *l*, which are placed on the internal ſurface of the eye, in the ſame manner as the ſeeds of the plant turnſol are fixed in their cups. All theſe fibres, which ſupport the glutinous matter aforeſaid, are connected together by the help of a membrane of a black colour on the inſide, but above of a tranſparent green on account of the matter; I therefore call it the uvea tunica.

The ſtructure and ſituation of theſe formed as it were an inverted pyramid, with its ſmall point turned downwards; but when I ſeparated theſe little fibres from each other, they appeared above as black as pitch, Tab. XI. fig. X. *m*, but below only of an obſcure or dark brown *n*, and pellucid in the middle *o*: all of them terminated at length in a gray ſubſtance, and under this the extremity of the optic nerve came in ſight.

When I viewed theſe fibres with a microſcope, I found each of them conſiſting of other fibres, fig. XI. *pp*, all which were compoſed as it were of regular globules placed near each other. Between theſe little fibres there appeared alſo ſome ſmall membranes, interwoven likewiſe in ſeveral places with globules, between which ſome veſſels appeared creeping in various directions.

The cornea tunica, which is entirely pellucid, is very beautifully ſituated on this eye, and ſhews a greeniſh tranſparent uvea underneath: where the eyes face each other, the cornea is beautifully divided, fig. IX. *i*, and the cruſt is there extended further; ſo that the cornea is placed on the eye like a little cap, lying on the head obliquely.

After what manner ſight is performed in the eye of the Hermit, and what effects are produced by the rays of light which paſs through the cornea, and the glutinous ſubſtance, and are afterwards ſtopt by the uvea, and thence communicate their motion to the pyramidal inverted fibres; this, illuſtrious Sir, I leave to your diſcerning and moſt correct judgment, not doubing but you will give me the ſolution of ſo peculiar a problem.

What I have here briefly related, Sir, is all I have been able, in this ſhort time, to diſcover in thoſe Hermits, which the governor of Nyenrode ſent me in ſpirit of wine. I offer you theſe obſervations in token of, and to preſerve, our mutual friendſhip, and as an example of the divine miracles, which ought to be adored in all animals. Indeed, if we diligently ſearched into nature, we ſhould for ever find more remarkable and more ſtupendous miracles, which hitherto lie hidden and wrapped up in the clouds of our ignorance. I hope to be at ſome time able to go through an accurate examination of the Caterpillar kind; in which, indeed, miſery, death, and the grand and ſplendid reſurrection of the body may be ſo clearly demonſtrated, that we ſhall ſee them as it were painted before our eyes, and muſt be obliged to cry out in amazement, that the great God, the parent of all nature, exceeds and ſurpaſſes all praiſe, all eulogies, and all titles of honour, in his miracles, which can never be deſcribed according to their dignity.

The SECOND ORDER.

Of the natural changes, or of the ſlow accretions in the limbs and parts of Inſects.

HAVING explained the firſt claſs of natural transformations in inſects, we ſhall now paſs to the ſecond, which, though ſomewhat more obſcure, may yet with due attention be clearly and diſtinctly underſtood. But before we proceed to explain this ſecond claſs, to which innumerable inſects are to be referred, it is neceſſary to obſerve, that in this order another ſpecies of transformation conſtantly precedes, which is indeed common to the two following, which are the laſt claſſes of mutations.

In order to underſtand accurately the preceeding kinds of tranſmutation in this, as well as in the two laſt claſſes, we muſt call to the attentive reader's mind what has been ſaid in the beginning of this work, where we treated of the firſt kinds of changes; that is, that ſome inſects iſſued perfect out of the egg, and others imperfect. As we have referred the inſects, which come perfect from the egg, to the firſt claſs of tranſmutation, it is very neceſſary to know, that this ſecond, and afterwards a third and fourth, or laſt claſs of mutations, precedes the completion of the parts in thoſe which iſſue imperfect in ſome of their parts out of the egg. Hence it is, that in the firſt order or claſs of changes, is peceived only one Nymph as it were, which we have obſerved is the egg or little creature itſelf. In the ſubſequent claſſes, on the contrary, we ſhall obſerve as it were two Nymphs in the courſe of the changes, and therefore two ſpecies of thoſe changes alſo ſince another kind of Nymph precedes the egg, or the oviform Worm of the Nymph.

That all theſe things may be perceived the clearer, we muſt briefly obſerve, that a little Worm always precedes this ſecond and all the ſucceeding orders of tranſmutations. After this Worm has been in its egg or firſt cover in the form of a Nymph, it increaſes by degrees in its limbs, and in proceſs of time becomes ſo perfect, that at length it puts on another habit of a real Nymph, and again becomes fluid like water in all its parts, and weak and feeble, or deſtitute of ſtrength, as it was before, when it was in the form of an egg. Hence it has happened, a matter not hitherto obſerved, that not only the ancient errors concerning theſe metamorphoſes remain to this day, but even thoſe moſt diligent ſearchers into nature, the ſagacious Francis Redi and others, declare they have ſeen the caſt skin, under which all the limbs and parts of the inſect increaſed; but never doubted concerning the metamorpoſes, at which we greatly wonder.

To ſpeak now in particular of our ſecond claſs of changes, it will be very proper to obſerve, that the accretion of the parts undergone in proceſs of time by the Worm, which is commonly found to have ſix legs, is inſenſibly and by degrees perfected by the evident external addition of matter; ſo that after ſome changes of its skin, we at length obſerve wings to ſprout inſenſibly out of the body, to ſwell and become fit to open and bloom, as a tender, ſmall, ſoft, delicate hull of a flower does out of a plant. Again, as in the other two changes, under which we ſhall ſee the Vermicles or Worms transformed into real Nymphs, the inſects are deprived of motion, and as it were of neceſſity lie unmoved for ſome time; ſo on the contrary, the inſect, under this change, advances, ſtands, walks, runs, leaps, and eats, nor is it ever deprived of motion, only that it reſts a little at the time it is to caſt its skin; and then ſtupendous changes happen in ſome of them, as is ſufficiently manifeſt in the Ephemera, or Day-fly. In others, on the contrary, the change is ſo inconſiderable, that it is with great difficulty obſerved, only about the protuberant wings, as is the caſe in the Earwig.

Since therefore the inſects which come under our ſecond claſs of changes, are not at any time deprived of motion, and yet have ſome of their parts well ordered, and compounded like other Nymphs: for theſe cogent reaſons we are induced to think, that the inſect may, at the time it exhibits its limbs and parts in the manner aforeſaid, not improperly be called a Nymph-vermicle; for the little creature, whilſt it is and remains a real Vermicle or Worm, has notwithſtanding ſome of its parts diſpoſed, and in an admirable manner beautifully compoſed, juſt as they are in the Nymph ſtate.

Our ſecond order or claſs of changes is therefore thus; the Vermicle or Worm having caſt off the habit of a Nymph, which it bore, without food in its egg, increaſes inſenſibly by the help of food ſupplied from without, diſcloſing many and more viſible parts, until it afterwards puts on as it were the form of another Nymph; but this without loſing its motion, and it afterwards comes out of that as a winged inſect; and having now attained as it were the marriage-ſtate, becomes fit for generation.

This is the ſpecies of Nymphs, to which we have given the ſecond place among the natural orders of changes, ſince the mutation in queſtion is not very intricate, nor is it obſcure or difficult to be underſtood; nay, it may with theſe rules be comprehended eaſily, and it approaches very nearly to the firſt order or claſs of changes, wherein we ſaw the creature iſſue immediately out of its egg or coat; nor does it indeed differ greatly from that order.

As this change is ſo clear and evident, and as it agrees ſo much with the budding and blooming of a flower, we have therefore thought proper to compare this, and the other ſubſequent changes, to this budding of plants. This is the more proper, becauſe, as the increaſe happens on the outſide of the creature, ſo it is likewiſe obſerved to happen in other inſects on the inſide, and under the skin; which has been ſufficiently ſhewn in the preceding pages, and ſhall be explained more at large hereafter. To conclude, as this change is very elegant, and very worthy of conſideration, it comprehends alſo a great many inſects under it.

A catalogue of the inſects, which are referred to the ſecond order or claſs of natural changes, called the Nymph Vermicle *.

TO this our ſecond order or claſs of changes we refer firſt the Dragon-fly, called the Mordella, or Orſodæna, by Junius; by Mouffet, Libella; and by Aldrovandus, Perla. I preſerve ſeventeen ſpecies of this genus, nine very large, five of a middle ſize, and three very ſmall ones, which, becauſe they are tender and delicate, are dignified by ſome under the particular name of Virgins. One of the ſmalleſt ſpecies is well deſcribed by Goedaert, but as this author neither delineates in its figure, nor takes any notice in its deſcription of thoſe ſwellings in the back, wherein the wings are incloſed, it is evident he did not know the nature or diſpoſition of this Nymph. Beſides, the third figure which he gives us of it, miſrepreſents nature according to the fancy of an imaginary brain. I never could find that it has hitherto been deſcribed by any other author. Among the figures publiſhed by Hoefnagel, who has given us the delineations of ten ſpecies of the Dragon-fly, there is found none of the Nymphs before mentioned; it is certain, however, that they were in general not unknown to authors. We find that Rondeletius knew the Nymph of the Dragon-fly, though he very improperly called it the Cicada or water Graſshopper. In like manner we believe that the Mordella is the water Locuſt of Mouffet. This is moſt certain, that the Forficula Aquatica of Johnſon, or otherwiſe the Pulex Marinus of Mouffet, is the true Nympha of the Mordella. The Scorpius Aquaticus alſo of Redi is nothing elſe but the Nymph of the Perla or Dragon-fly, but belonging to a ſpecies which we reckon among the larger Virgins.

I keep in my collection, ſix kinds of the Nymph Vermicle, from which Dragon-flies have their origin; there are one very large, three of a middle ſize, and two ſmall. I have likewiſe a Dragon-fly, which was to have undergone a change immediately, and in which one may obſerve, in what a wonderful manner the wings are wrinkled and folded in the tubercles on the back, wherein they are encloſed. I preſerve beſides the ovary of the Dragon-fly, which is perfectly like that of fiſh, divided into two parts, one whereof is placed in the right, the other in the left ſide of the abdomen.

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* The famous inſect, the Formica Leo, is a Vermicle of one of the Flies of this kind. This creature naturally walks backward. There is another ſpecies which moves forward; theſe are found on land. The more frequent kinds are thoſe of the water, and they are common in our ditches.

The ſecond inſect which we reckon in our ſecond claſs of changes is the Graſshopper. I preſerve one and twenty ſpecies of them male and female; theſe are nine larger, ſix middling, and as many ſmaller ones, whereof ſome are conſpicuous by their ſcarlet wings, others are cloathed in purple, others in azure, and others have elegant greeniſh wings. I preſerve alſo ſome Nymphs, ſome Vermicles, and ſome little eggs, from which proceed the Graſshopper and Locuſt kinds. Amongſt the largeſt ſpecies, I have the great deſtructive African Locuſt, which has a cowled or hooded breaſt, and two very long legs, which, as they have hexagonal thighs, are provided alſo with a double row of ſerrated and long teeth; the internal wings glitter with a deep purple colour. This belongs to thoſe ſpecies, which do not ſhew their colour except when they are flying. I have alſo the Locuſt of the Molucca iſlands, which Dr. Padbrugge ſent me. It has a very ſlender body like the Cavallucus of Redi, and the tail is bent downwards. Its wings are long, and of various beautiful colours like the Peacock. The neck is of uncommon length, and ſupports a ſhort head. That gentleman ſent me alſo a figure of the Molucca Bruchus, or Grub, the body whereof is as big and as thick as a Hen's egg, and is beautifully interwoven with veins like ribs, but the legs are very ſhort in proportion. I preſerve with theſe the Spaniſh Locuſt, which differs from the African only in its ſize, except that the veins in its wings are diſpoſed in a different manner, and the colour is reddiſh. I have alſo the African Locuſt with ſhort legs, and ſhort thick horns, wherein one may, in a remarkable and diſtinct manner, ſee the prominent eyes. Among the middle ſpecies I preſerve the Mantis or divining Locuſt, which was likewiſe brought from the Molucca iſlands. Of this authors invent many idle ſtories; one is, that when it is aſked the way by travellers, it ſhews it. "This little creature is reckoned "of ſuch a divining nature, ſays Mouffet, that "when a boy asks for the way, it ſtretches its "foot forward and ſhews it, and is ſeldom or never miſtaken." The other Locuſts that I preſerve are of the middle ſize, and moſtly french; they are adorned with a wonderful variety of colours, as with ſo many new-faſhioned garments: hence they pleaſe the eye greatly with their natural ornaments, but they do not ſhew their colour except when they fly.

It is remarkable what ſmall difference there is between the Worm or Nymph Vermicle of the Locuſt, and the Locuſt itſelf: this conſiſts only in one thing, that the wings, which in the Locuſts are expanded and ſpread over the body, are on the contrary encloſed in the Nymph, in four little cluſters, wherein they are quite folded into each other, in like manner as in the Worm of the Dragon-fly. It was this folding and ſeparating of the wings, that, in my opinion, made Ariſtotle, Pliny, Hieronymus, Aldrovandus, Mouffet, Johnſon, and other curious ſearchers into theſe ſecrets, call the aforeſaid Vermicles of Locuſts, featherleſs or unfledged Locuſts and Bruchi. The ſame creatures they afterwards, when their wings began to ſwell, called Attelabi; and to theſe, when by the increaſe of the bulk of their bodies, eſpecially theſe of the females, they began to hop ſlowly, but were not yet able to fly, they gave, not to mention many other names, the appellation of Aſelli. The word Attelabus properly ſignifies the Nymph of the Locuſt when able to walk. We ſee ſeven ſpecies great and ſmall of theſe Nymphs, out of which the Locuſts iſſue. In the figures of the induſtrious Hoefnagel, which exhibit fifteen ſpecies, we likewiſe ſee there a delineation of the Nymph Vermicle of the Locuſt. When I conſider all theſe experiments, I cannot imagine for what reaſon Goedaert ſhould write, that Locuſts had their origin from a Chryſalis; ſince Aldrovandus and Mouffet, and all other authors make mention of unfledged Locuſts, and their opinion is ſupported by, and agreeable to, experience.

I preſerve alſo a three-fold ſtomach of a Locuſt, which is very like the ſtomachs of animals that chew the cud, and particularly has that part of the ſtomach called Echinus, very diſtinctly viſible. I do not therefore doubt but Locuſts chew the cud, as well as the animals juſt mentioned: indeed, I perſwade myſelf that I have ſeen this.

I have likewiſe in my poſſeſſion, the oblong eggs of Locuſts and their entire ovary, which is interwoven with ſilver-coloured filaments, which are doubtleſs ramifications of the aſpera arteria, and alſo with veins and arteries. But the eggs are all as it were horny, and of a brown colour: many of their firſt rudiments alſo being white and yellow, and covered with a thin coat or skin. I preſerve theſe in particular cells in my cabinet.

The female Locuſts are furniſhed with ſharp tails, which the males have not. According to Aldrovandus, they pierce the ground with theſe tails, and bury their eggs under it. I can demonſtrate this tail to be quadruple, nay, quintuple.

I preſerve alſo the teeth of Locuſts, and the coat or skin which the Nymph Vermicle caſts, when the wings of the Locuſts begin to ſwell. No man can form any idea, by what means a very thin skin is then ſeparated from the long and ſmall horns of the Locuſts; nay, and from the eyes and teeth, and the ſharp-pointed claws. In this period the Locuſts are ſo ſoft and delicate, that their legs may be bent like wax, and formed into any figure, and in that condition may be dried and preſerved.

I have alſo wings of Locuſts which I ſtopped in the act of their excluſion; ſo that by this means one of their extremities is diſplayed or rolled out, and the other ſtill folded together and wrinkled. With theſe wings the Graſshoppers and Locuſts, when they have gone through their change, make that crackling noiſe, as Caſſerius has very juſtly obſerved. We alſo find that the males of Locuſts only make this noiſe, not the females: indeed ſome ſpecies make this noiſe with their wings only, and others by ſtriking their wings and legs together.

The Locuſta Pulex, or Flea Locuſt, follows. This little creature is found hid in that ſpumous matter, which we ſometimes ſee lying indiſcriminately on the ſurface of all kinds of plants*. In this ſpume † it acquires in time four tubercles on its back, wherein the wings are encloſed. I have two ſpecies of this inſect, and it was likewiſe known by Mr. Ray, who deſcribed the plants growing about Cambridge. It has not teeth like the Locuſts, but has only a ſubtle ſharp-pointed proboſcis or trunk, like Graſshoppers, on its breaſt.

We refer alſo to this ſecond claſs the Gryllus Sylveſtris, or wood Cricket; in which inſect we alſo obſerve that the male only ſings, or makes a noiſe. I remember that I once ſaw a whole field full of theſe ſinging Crickets, each of which had dug itſelf a hole in the earth, two fingers deep, and then ſitting at the entrance thereof, they made a very diſagreeable noiſe with the craſhing and tremulous motion of their wings; when they heard any noiſe they immediately retired, trembling, into their little caverns.

The houſe Cricket is the next to be reckoned in this ſecond claſs; ſince this, like Locuſts, has alſo its wings encloſed in little caſes, as long as it remains in the habit of a Nymph.

We likewiſe rank the common Graſshopper in this claſs. For although the larger Graſshoppers are not found in our part of the Netherlands; we, notwithſtanding, by inference from the leſs to the greater, refer them to this place; and the rather, becauſe the very diligent Aldrovandus hath left us a delineation of this Worm, with its tubercles on its back, wherein the wings like a flower in its cup are encloſed; as this Worm is called Tettigometra by him, it is the real Nymph of the Graſshopper. I preſerve a very rare and curious exotic Graſshopper, the head of which is formed like a long and deep epiſcopal mitre, ſo that it appeared four fifths of an inch above the eyes, exhibiting us a wonderful work of God in the theatre of nature. We muſt alſo obſerve again, that the male Graſshoppers only can ſing, and we can ſhew their tympanum, and alſo the little part that modulates or tunes the voice, or impels the air againſt the tympanum.

The Gryllo Talpa or Mole Cricket, or the Talpa Ferrantis Imperati, likewiſe belongs to this claſs; ſince, like the inſects hitherto deſcribed, it has four tubercles on its back, wherein the wings are encloſed. We have the Worm of this inſect with and without tubercles, as alſo the inſects themſelves, with their wings diſplayed. The induſtrious Goedaert has deſcribed the egg of this inſect. We can alſo ſhew its teeth, and the manner wherein the wings lie complicated in their tubercles.

In this I alſo reckon a little creature, which is found in the tubercles of the leaves of the black poplar, though I might have deſcribed it in the fourth order or claſs, becauſe it has a more ſecret method of changing. It is delineated in figure XXIV. of Tab. XLV. To this order I likewiſe refer another inſect, which is likewiſe repreſented in fig. VII. of Tab. XLIV. and is found in the tubercles or ſwellings of willow trees.

The next we exhibit is the Indian inſect, ſufficiently known by the name of Kakkerlak, which we think likewiſe belongs to this ſecond claſs. As we have obſerved the tubercles beforementioned in its wings, though not having attained their full bigneſs their wings did not appear perfect; for the ſame reaſons, we think we ſhould refer to this order that ſpecies of Beetles which are commonly found about bakers ovens, and, according to Fabius Columna ‡, in kitchen dirt. They agree altogether with the inſects juſt now mentioned, called Kakkerlak, and are the ſame that are deſcribed by Mouffet under the name of Blattæ. We preſerve two ſpecies of them, together with their Nymphs, wherein the tubercles ſcarce began to ſwell.

Next follow the flying or land Bugs, which we find in fields and trees. I preſerve twenty-ſix ſpecies of them in my muſeum, together with a larger Indian one, which are very beautifully adorned by nature with variety of colours; and as with their luſtre and gaiety they wonderfully pleaſe the eyes, ſo they are very diſagreeable to the ſmell. Hoefnagel alſo has figured eleven kinds. Among theſe which are in our cabinet, we reckon the cruciate, the ſcarlet, the red marked with black lines, the green, the black, the yellow, the globular, and that which has a ſharp-pointed breaſt.

To this claſs we likewiſe refer the flying water Cimices or Bugs, of which we preſerve four full-grown ones, and one Nymph. Theſe, like all the reſt, carry their weapon in their mouth, and ſting vehemently therewith, as I have ſometimes experienced myſelf, though I ſuffered no injury thereby.

We refer alſo to this order or claſs ſome inſects that are very tender and ſlow-paced, having ſix ſlender and admirable legs, and long and acute horns, and a conſiderable thick body; from the hinder part whereof, about the tail, ſpring two briſtly and ſharp-pointed hairs, and they have likewiſe a ſharp ſting, as the Cimices or Bugs, ſo that they ſeem likewiſe to belong to that genus. I could never hitherto obſerve theſe little creatures to change: but they are found on various plants, and there become often immoveable. Laſtly, I preſerve a very ſlender kind of Fly, which firſt iſſues from a Worm which was in the body of that creature, transformed into a Nymph of the third claſs. But if this Fly creeps out of the body of this inſect, after preparing a paſſage for itſelf through a ſmall hole which it makes with its teeth, then all the body is hollow, and the dead inſect remains in the ſame ſituation as if it were ſtill living *. Theſe little creatures, hitherto not accurately enough examined, are improperly called the Lice of plants. I have ſome of them, and alſo the flies that come from them.

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* This is a ſpecies of the Cicada or Cigale. The characters of that genus are very obvious on it: they are, that the beak is under the breaſt, and is bent downwards; the antennæ or horns very ſhort; the wings four, and placed croſs-wiſe, the back conciſe, the breaſt cylindrical, and the legs made for hopping. The Cicada of Italy, which the Roman poets mention, and which their tranſlators render Graſshopper, is of this genus. We have alſo one on the roſe, and others on various buſhes.

† This ſpume is not exſudated, as ſome ſuppoſe, from the plant, but from the mouth of the animal; and if it be well wiped away, without injuring the creature, more will be immediately ſeen iſſuing out of its mouth, till there is as large a quantity of it as before.

‡ Obſ. aq. et terr.

We likewiſe place in this order the water Tipula, of which I preſerve many ſpecies, and one of the Nymph. Theſe inſects are worthy of the greateſt attention, on account of the wonderful lightneſs wherewith they run on the ſurface of the water. They have an aculeus or ſting, like Bugs, in their mouth. I preſerve beſides another ſpecies of this inſect, which is of a wonderful delicacy, and of a very ſingular ſtructure, and very ſlow-paced.

In like manner we inſert in this claſs the water Scorpion, which has alſo an aculeus or ſting in its mouth. I preſerve two ſpecics of it, the larger whereof is deſcribed by Aldrovandus under the name of the water Tipula, and the leſs by Mouffet retaining the name of the water Scorpion. I have a Nymph of the ſmaller ſpecies, in which may be ſeen how the wings bud or diſcloſe themſelves by degrees, as is the caſe in the Nymphs of the Dragon-Fly in this ſame claſs.

The common water Flies are likewiſe of this order. Of thoſe I preſerve four ſpecies, and we have often ſpoken of the Nymphs and Worms out of which they iſſue when ſmall. Theſe, like other water inſects, likewiſe have their ſting in their mouth, and they defend themſelves therewith, whenever they are attacked or taken. Theſe Flies are called amphibious Bees by Aldrovandus, and are very accurately deſcribed by him. They are alſo called wild Bees by Johnſon: nor do I doubt but theſe are the ſame with the Marinæ or Sea Bee, which has been deſcribed by Dr. Piſo, and is now in the poſſeſſion of Vander Linden, doctor of phyſic; but it appears to be nothing elſe but a piece of ſponge. The learned Mouffet calls theſe Flies Notonectæ, becauſe they do not ſwim on their belly, but on their back; and he ſeems to have likewiſe delineated the water Bug among the Notonectæ, ſaying, that it is probable men learned the art of ſwimming on their backs from them. How far this may be admitted, let others determine.

As all the inſects hitherto enumerated have wings, ſome of them flying in the day-time and others at night, it is eaſy to conceive that they may be very ſpeedily generated in all ſtanding waters. And therefore in ſummer-time a kind of trembling motion is frequently obſerved to be excited even in the ſmalleſt ditches of water by the motions of inſects. But we ſhall ſpeak of theſe matters more at large in their proper places.

Laſtly, we likewiſe refer the day Fly, Ephemera, to this order: its eggs and ovary, which is like that of fiſh, we preſerve in our cabinet. We alſo have in our poſſeſſion the Worm and Nymph Vermicle, and alſo the Ephemera itſelf, both male and female. We can from theſe objects demonſtrate how the wings are rolled and folded in the tubercles of the Nymph Vermicle, for there is an admirable difference between the folds of theſe wings, and the complication of the wings of the Dragon Fly. We alſo obſerve the like difference, with reſpect to the diſpoſition of the wings in other inſects, as will be ſhewn from our particular obſervations, to the praiſe and glory of the moſt admirable Creator. After this, we ſhall in its place, from the courſe of our experiments, aſſign a reaſon, why the wings in theſe inſects are diſpoſed in ſuch a particular manner, the knowledge of which will doubtleſs be acceptable to the reader.

I preſerve likewiſe the one day Flies, fixed in ſuch a poſition, that it is very eaſy to perceive the method whereby they caſt a very thin skin like a ſhirt from their whole body, which is wonderful to look upon, and difficult to be expreſſed in words. At one end of this skin they roll or turn themſelves out, as the foot is taken out of the ſhoe, and at the other end they turn it off in the ſame manner as a man takes off his glove by turning the inſide outwards. All this will become evident, when we deſcribe our particular obſervations on this ſtupendous miracle of the Netherlands, and what we have remarked concerning the uncommon, very ſwift, and as it were horary changes of this little creature; that they may afford perpetual matter of meditation on the incomprehenſible wiſdom of God, and regular order of nature. In the mean time, we think what Dr. Augerius Clutius hath not ſcrupled to affirm, very improbable; and that is, that the Ephemera, or day Fly, is produced from a Chryſalis, and he has likewiſe exhibited the figure of this Chryſalis contrary to all truth. We obſerve that its figure is ſubjoined or added alſo to the track of Goedaert; but theſe are delineated upon the ſuggeſtions of a weak fancy. This will be very evident, when the inſects themſelves, which the learned Andrew Colvius ſent us, are compared with thoſe figures.

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* Since the time of this writer, Reaumur has with great judgment and knowledge written of many of theſe creatures. They run about the branches of trees and ſhrubs, while ſmall, and when they have paſſed part of their lives thus, they remain immoveable for the reſt, and their bodies become only a kind of covering for numerous genus. That author calls them gall inſects, and progal inſects. The Kermes and Cochineal are of the ſame kinds.

I have in my poſſeſſion ſeveral ſpecies of the Ephemerus collected in France and other places; among which I can ſhew the leaſt ſpecies of the Hemerobius or Ephemerus, called in Dutch Mut; the wonderful changes whereof I have ſhewn as a matter of the higheſt ſpeculation, to the moſt noble Thevenot, the illuſtrious patron of all our ſtudies, in the road that leads from Amſterdam to Sloten.

Before we conclude this order, we ſhall refer the Earwig, Forficula, or Auricularia thereto, which creature, with its wings viſibly expanded, and its Nymph-Vermicle are alſo preſerved in my collection.

We claſs or arrange in this order all the inſects that we have hitherto deſcribed, which are excluded from their eggs under the form of a Worm, and in proceſs of time are augmented or increaſed into Nymph-Vermicles and ſo on. Nor can we ſufficiently wonder that this order of change has not been hitherto obſerved or repreſented to our knowledge by any perſon. So that upon conſidering how little the naturaliſts have taught us concerning theſe creatures, we are obliged, not without ſhame, to confeſs, that they were wholly ignorant of the nature of moſt inſects. For, if we may expreſs the matter as it really is in a few words, the names only of the ſaid inſects are mentioned in the books of the naturaliſts, and if you except theſe, nothing remains but the falſe and imaginary inventions of a dreaming and chimerical brain. As I am not afraid to declare this generally, I would always except the induſtrious Goedaert, who has faithfully delineated, and, in ſome meaſure, according to truth deſcribed the changes of the Caterpillar kind; as alſo the moſt accute Redi, who has, by irrefragable arguments, proved, that no creatures are produced by putrefaction; and laſtly, ſome accompliſhed Engliſhmen, the chief of whom are John Ray and Martin Liſter.

An example of the ſecond order or claſs of natural changes, which I call the Nymph-Vermicle, in the Dragon-Fly.

N°. I. I EXHIBIT here, Tab. XII. the Vermicle or Worm of the Dragon-Fly, as yet lying in its firſt coat, in which, when encloſed, it is called an egg. Many of theſe eggs, placed near each other in the ſame manner as they are ſituated in the divided ovary of the Libella, I here exhibit delineated to the life. This ovary perfectly agrees with that of fiſh, eſpecially that of the Herring, and conſiſts in like manner of numerous eggs, which are of an oblong figure, as may appear from thoſe diſperſed here and there in this figure. The eggs encloſed in this ovary are at length thrown into the water by the parent inſect, out of which afterwards iſſue many ſmall Vermicles with ſix legs; and theſe having attained the full period of their growth, caſt their skins, and becomes ſo many Dragon-Flies, like the parent.

II. To ſhew the method wherein this happens, I have likewiſe, for the ſake of order, delineated to the life the coat of the egg out of which the Worm of the Fly has made its way.

III. I afterwards in the third place, ſhew the Vermicle or Worm from which the Dragon-Fly is produced, by the power of accretion alone, but I have not delineated it ſo ſmall as it is when it comes firſt out of its egg, but ſomewhat larger, and in the form it has when it has been fed for ſome time. I ſhew its eyes, together with two prominent horns in its head: in the breaſt underneath are obſerved ſix ſhaggy legs, each of which is divided into four joints, and the extreme joint of each is furniſhed with two claws. The belly is divided into ten rings, the laſt or loweſt of which has ſome briſtly, rigid and prominent little points. It is agreeable to obſerve in this Worm how its limbs come imperfect out of the egg, which is likewiſe a property of the Vermicles of the third and fourth order or claſs of tranſmutations, as ſhall be afterwards ſhewn in its proper place. And it is for this reaſon I call the little creature, whilſt it remains in this imperfect form in the egg, an oviform Nymph-Vermicle, as I have explained more at large above; and this obſervation I would have inculcated and underſtood once for all, in the courſe of the ſubſequent orders, as I ſhall repeat it no more.

IV. I repreſent this Vermicle ſomewhat older, ſo that about the end of the thorax, where that part is connected with the belly, four membranous buds or follicles like flower-cups are obſerved to ſpring, ſwell, and as it were branch out of the body: theſe four follicles or membranous bags contain the wings, which increaſe in the ſame manner as the cups of plants and trees do with their flowers and fruit. But if any one ſhould at this period diſſect theſe bags, he would find nothing in them but a watry humour or ichor, becauſe the wings, too tender yet for ſight, have not acquired their ſtrength and perfection, in the ſame manner as in the cups of flowers and fruits when they are firſt diſtinguiſhable, nothing is found but a moiſture or clammy liquor.

V. I afterwards demonſtrate this little creature in the ſtate wherein it has attained its full bigneſs, together with its four bags or follicles, which are conſpicuous on its back, and are increaſed to their due ſize; at this time I find the wings perfect in them, but folded in each other; nay, we may likewiſe obſerve all the colours and varieties of painting of this creature now tranſparent through the skin:

wherefore, as the inſect is and remains yet a Vermicle or Worm, and has ſome of its parts encloſed in a ſkin and deprived of motion, like a Nymph of the third order or claſs, I have called it in this period a Nymph-Vermicle. In what manner this Nymph caſts its ſkin, is ſhewn in the ſecond figure, Tab. XII. fig. II.

VI. Laſtly, I exhibit the ſame Vermicle as it is when arrived to its laſt degree of perfection; in which form it is called the Perla, Libella, or Dragon-Fly, and by increaſing becomes a perfect creature, becauſe it has acquired its full age and is now fit for generation. As at firſt it was a creeping and ſwimming Worm, it is now become a flying Worm or inhabitant of the air. Moreover, its change, or properly the accretion and expanſion of its parts, is, with reſpect to its eyes, wings and tail, extremely admirable, but the legs undergo no change.

I firſt obſerved theſe Worms, out of which the Dragon-Flies are produced in the river Loire at Saumur, behind the houſe of the very learned Dr. Tanaguil Faber, whoſe gueſt I had then been, and who likewiſe greatly loved to ſearch into ſuch natural miracles. I afterwards found them in many other freſh rivers, ſmall pools, fenny ditches, and other ſtanding waters, and in ſome places in ſuch great numbers that the whole bottom was as it were planted with them. They can both creep and ſwim, but they do not move ſwiftly. They have likewiſe a ſharp ſight, and they immediately throw themſelves to the bottom, if any one comes to the places wherein they live, or when they perceive the leaſt uncommon object. Their food is ſoft mud, and a fine earthy ſubſtance; wherein they live. They are produced by the Libellæ or Dragon-Flies, for theſe are likewiſe uſually about waters, and in thoſe places perform in a very wonderful manner the buſineſs of generation. Numerous Dragon-Flies are likewiſe found in the fields and foreſts, where there are numerous ſmaller Flies; for, like birds of prey, they hunt after and devour the latter in the air.

If the eggs which the Dragon-Flies throw into the water be examined with a microſcope, they appear of an oblong figure, Tab. XII. fig. I. and in the fore part terminate in a point: in this part they are alſo adorned with a kind of little cups, with protuberant points, ſomewhat reſembling the cups which we have delineated in the Nit or Louſe's egg, and they are blackiſh in the extreme fore end. At the hinder part the egg terminates in an oval form, and has a glittering ſurface; beſides this it has nothing ſingular in it.

When the Worms which iſſue out of theſe eggs have grown to the form of a Nymph-Vermicle, they then remove out of the water to a dry place, as into the graſs, to pieces of wood, or a ſtone wall, or any thing elſe they meet with; and therein firmly fixing the acute claws, Tab. XII. fig. II. *a a*, of their legs, they continue immovable a very ſhort time. It is then obſerved, that the ſkin firſt opens in their head and back; and out of this opening they exhibit to view their real head and eyes *b*, and at length their ſix legs *c c*; whilſt in the mean time the hollow and empty ſkin or ſlough of the legs remains firmly fixed in its place; after this the encloſed creature creeps forward by degrees, and by this means draws firſt its wings and then its body out of the ſkin, and proceeding a little further, ſits at reſt for ſome time longer as if immovable. In this time its wings begin by degrees to expand themſelves, and to make ſmooth and even all their plaits and folds. The body is likewiſe inſenſibly extended, until all the limbs have obtained their juſt ſize and bigneſs. As all theſe things are perfected by the force of blood and circulating humours, and by the aſſiſtance of the air impelled by reſpiration, the creature cannot the firſt moment fly, and therefore is forced to ſtay in the ſame place, until all its limbs are dried by the circumambient air and ſun. Thus the Dragon-Fly enters upon a more noble life than that it had hitherto led in the water, for in the latter it was obliged to live in miſery, creeping and ſwimming ſlowly, but now it wings the air.

It is very ſeldom that theſe changes of inſects are preſented to view by nature, and it happened by mere chance that I obſerved them for the firſt time: one of theſe Vermicles adhered to a ſtone wall in the river Loire, and it was ſo ſoftened by the waves daſhing againſt it, that it could only half perfect its change, ſo that I took it partly free, and partly yet fixed in the ſkin. I once afterwards ſaw this change in the large kind of Dragon-Fly, which had crept to land out of a ſmall lake, and caſt its ſkin ſitting in the graſs. In the ſmalleſt Dragon-Flies, which are very numerous in Holland, and of which Goedaert has deſcribed the mutation, it is not ſo difficult to diſcover this matter, as I have long ago ſhewn it to many, and amongſt the reſt to Dr. Matthew Slade.

Another thing worthy of obſervation in theſe creatures is, that they muſt hunt and ſeek after their food flying in the air, for which purpoſe nature has given them two large eyes, which make almoſt the whole head, and are like glittering mother-of-pearl. They have moreover four remarkable membranous ſilver-coloured wings, with which, as with oars, they can turn themſelves like ſwallows with a prodigious velocity to all parts of the air. But to this the very long tail that they have is alſo conducive, for with this they ſteer and govern themſelves with great art, and prepare themſelves a certain path through the air. Mouffet, who erroneouſly aſſerted, that theſe creatures were produced from rotten bull-ruſhes, ſpeaks however very rationally of them, when he ſays: "They form one of the greateſt beauties in all "nature, being ſuperior by far to all art."

The eyes of the Dragon-Fly are of a reticular ſtructure, and are divided by a double ſeries of interſections, as I have deſcribed in another place. Within the mouth are to be ſeen two teeth, covered with a beautiful lip; with theſe the creatures bite fiercely when they are taken: and it was probably for this reaſon that Junius gave them the name of Mordellæ. But whether their bite be venomous, or raiſes a bliſter in the skin, I have not hitherto obſerved.

Since the Dragon-Flies have very large and long wings; and, on the contrary, very ſhort legs in proportion, it is not agreeable to them to walk on the ground, and the more, becauſe when they walk, they do not raiſe their wings, nor keep them cloſe on their back, like the Butterflies. For which reaſon they always chooſe dry branches of trees, on which they pitch when they want to reſt or have catched their prey, which they ſeize with their ſix legs in the air, convey into their mouth with their two foremoſt legs, and then break it in pieces with their teeth. In this they do not ſpare the melliferous Bees; they catch them in the air and deſtroy them. Theſe Flies cannot be kept alive long in a box, unleſs they are fed every day with Flies, which they like to eat. They are greatly delighted with the rays of the ſun, to which they are indebted both for life and motion; for, when the heavens are cloudy, and the air obſcure, they reſt and do not eat, having then very little motion.

The thorax, on the inſide, where the wings are fixed to the ſhoulder blades, exhibits a large number of muſcular fibres, which ſerve to move the legs and wings. Through theſe fibres paſs the heart, gullet, and ſpinal marrow, the greateſt part of which are placed in the loins and belly. But as I have not hitherto perfected the exact anatomy of theſe creatures, I cannot advance any more particulars concerning them. The ſtomach is ſhaped like a pear; I have once ſeen it full of food, and at another time full of air. The pulmonary veſſels are likewiſe numerous here. One may likewiſe diſtinctly ſee the muſcular fibres, which I never ſaw agitated with any remarkable motion.

The male hath its penis placed about the beginning of its belly, the female on the contrary has the orifice of the vulva, in the extremity of her tail; but I have not accurately viewed theſe parts, ſince, in order to make the diſſections, I ſhould have taken out the entrails of theſe inſects firſt, that I might preſerve the whole form of their bodies. This may be eaſily done, if one takes out the viſcera, and afterwards ſprinkles the parts, which are ſtill wettiſh on the inſide, with plaiſter of Paris, or unſlacked lime, which imbibes the moiſture. By this means a very elegant ſpecimen of the tail, breaſt, and eyes, may be preſerved; and this contrivance is likewiſe made uſe of by painters and engravers. There is upon all theſe occaſions a neceſſity for a cautious and circumſpect dexterity, which cannot be acquired but by frequent exerciſe, and is not to be taught by words.

Though the Dragon-fly is, in every reſpect, a wonderful creature, and has its genital organs placed in a very ſingular manner in its body; its act of coition in particular exceeds or ſurpaſſes all the powers of our imagination. The male, fluctuating and riſing up and down in the air, and cutting it with many convolutions, knows how to ſtretch or hold out its tail with wonderful velocity to the female, Tab. XII. fig. III. *a*, who places it between the diviſion of her head and eyes, and guides it into her neck, and then, cloſely embracing it with her legs, receives it very pleaſingly *b*; then ſhe immediately bends and turns her body toward the breaſt of the male *c*, where the maſculine organs of generation are placed near the upper part of the belly; and thus continually flying and panting, they perform the buſineſs of coition in the air. By this means the extremity of the female's tail is bent back, towards the middle of the male's body, that is toward that part where the penis lies, which is received by the vulva of the female, placed in the top of her tail; but that the female may the more conveniently reach to that part, the male ſhortens himſelf as it were, and bends and contracts his tail conſiderably.

The female being thus impregnated, after ſome time dips her tail into the water, and throws her eggs into it. Theſe eggs, as I have already obſerved, are oblong, and while they are ſmall and imperfect, they are ſomewhat tender and whitiſh, but afterwards they by degrees grow hard and yellow, having a blackiſh point at their end. How long ſuch an egg remains in the water before the Worm is produced from it, is as much unknown to me, as how long it is increaſing from that time until it changes its skin; but I ſhould think two years are neceſſary for this purpoſe, ſince I have obſerved that theſe Worms were at the end of the ſummer very far from a ſtate of perfection. I have ſometimes ſeen in France ſo great a number of them in a clayey ditch that had no water plants in it, that they covered the whole bottom.

Of the various ſpecies of the Nymph-Vermicles of the Dragon-Fly.

AS I have obſerved in the general enumeration of theſe creatures, that I kept ſix of the Nymphs, one of which I have before delineated, Tab. XII. N°. V. I ſhall now repreſent and briefly deſcribe four others. The firſt belongs to one of the largeſt Dragon-Flies, in the head whereof are obſerved two equal, but not reticular eyes, fig. IV. *a a*; before theſe are placed two horns *b b*, and under the latter may be ſeen the three diviſions of the mouth, whereof the two upper are provided with teeth *c*, which may be moſt properly called ſo, only I think them too delicate and tender. Underneath at the breaſt are ſituated ſix legs, which have two ſharp claws *dd* at their extremities, and are variegated with green, yellow and other coloured ſpots. In the upper part of the back, under the ſhoulder-blades, may be ſeen very diſtinctly four membranous cups, wherein are encloſed *ee* the wings folded into each other; ſo that it is hard to underſtand how or by what means ſuch ſtrong, broad, long and remarkable wings as the largeſt Dragon-Fly has, could be contained within ſo narrow a compaſs. But this matter will be eaſily underſtood by any perſon who attentively conſiders what a large number of leaves lie folded up in the globular cup of the double poppy; for the wings beforementioned agree very well with thoſe leaves in the manner of their lying.

The abdomen is divided at the margin of the belly into various ſharp and rough diviſions *ff*, the rings whereof are, where they branch out, adorned with many tranſparent colours. The tail is divided as into five parts, which, whilſt the little inſect lives, reſemble ſo many pyramidal rough prickles or ſtings *g*, each of which caſts it ſkin, when the Nymph aſſumes the form of a Dragon-Fly: theſe ſerve principally to cloſe up the fundament, and are likewiſe an ornament to the hinder part of the body. But in the males they have another uſe, that is, to keep the creature in coition firmly fixed to the head of the female, and join themſelves with the neck of the latter, as I have exemplified in the third figure of the middle Libella, Tab. XII. fig. III. In my laſt obſervations I alſo remarked, that the branches or ramifications of the Aſpera Arteria likewiſe ſhed a coat or ſkin: and in this reſpect it agrees with all other ſpecies of Nymphs, and with the Worms and Caterpillars of Butterflies and other inſects.

The other Nymph Vermicle that I exhibit is likewiſe of this ſpecies, from which the middle Dragon-Flies are produced. It has all thoſe parts I have before ſhewn in the largeſt. The lips only and teeth are placed in a different manner, and are obſerved to be longer, fig. V. *a*, though they may be likewiſe lengthened or drawn out in the largeſt Nymph. The legs alſo are ſhaggy *b*; the follicles or bags are likewiſe diſtinctly ſeen on the back *c*, as well as the rings of the abdomen, and prickles or ſtings in the tail *d*. I found the former largeſt Nymph in a ditch upon ſome water plants, after it had firſt crept into the graſs and caſt its ſkin. In the Nymph juſt now deſcribed the wings were ſo perfect, that they might be ſpread open or diſplayed in the hand.

The third ſpecies I exhibit is not found in Holland, except in the diſtrict of Utrecht. I firſt found this Nymph on the other ſide of Paris in the river Seine, where many ox ſkulls had been thown into it, and theſe being filled with mud afforded the Nymph habitation and nouriſhment. I likewiſe found there many river Hermits, which probably prey upon theſe and the like inſects. This is probably the little creature that Redi calls the Marine Scorpion; and delineates without follicles or bags of wings, becauſe he had not ſeen it completely perfect. Of the ſame nature with this inſect is alſo that which Rondeletius calls the Marteau and river Libella. In the head of this inſect are likewiſe obſerved two eyes, without diviſions; before which are two articulated horns or antennæ, fig. VI. *a*. It has ſix legs, which are long enough for the bigneſs of the body *b b*. The four bags or follicles annexed to the ſhoulder-blades are preſſed together cloſe and even; and are beautifully marked, Tab. XII. fig. VI. *c c*, with intercurrent veſſels. The body is divided into rings, and is all over briſtly *d*. The tail was painted with green and yellow, and divided as into three triangular appendages *e*. This little creature ſwims faſter than the former Nymph; but the Fly again iſſuing from it, has a ſlower motion, and prides itſelf in very beautiful wings, which are variouſly painted, according as theſe Nymphs differ among themſelves. Whoever attentively views the wings of this Dragon-Fly, will ſee that their nervous diviſions are much cloſer than in the wings of the largeſt and middle ſpecies; nay, this differs from them in this, that it folds its wings like the diurnal Butterflies, when it lies any where to reſt.

I have a Spaniſh Dragon-Fly, which has ſharp pointed wings, and therefore differs from all others; for the wings of ours are for the moſt part oval, and terminate in a roundiſh extremity. It has likewiſe very large hairy horns or antennæ. I have myſelf delineated to the life another kind of Dragon-Fly ſent from Africa, which had ſpotted wings. I likewiſe have ſeen a third ſpecies, which had very long and broad wings, and but a ſmall body in proportion: but the wings were conſpicuous and remarkable for ſome paintings on them like dried vine-branches, and exhibited a ſpectacle of the moſt exquiſite art and admirable elegance. I have therefore delineated this in its natural ſize, and can ſhew a preparation of it to this day.

The fourth ſpecies of theſe Nymphs is found every where in the waters in Holland, but eſpecially in the narrow ditches; out of which, with the water plants, ſuch Nymphs may be taken almoſt every year, not excepting even the winter. They do not differ much from that juſt now deſcribed, as is manifeſt from the figure, fig. VII. This Nymph, having caſt its skin, produces a very ſmall Fly, with ſilver-coloured wings, and a blue and black body. This kind has alſo a ſlow motion, and almoſt perpetually flies about ditches. This ſpecies of Dragon-Fly has the ſame method of generation with the largeſt and middle kind, for both perform the buſineſs of coition in the air. But I muſt confeſs I never ſaw the manner wherein theſe Flies that iſſue out of the Nymphs delineated in fig. VI. propagate their ſpecies.

Of the flying Water Scorpion *, *which belong to our ſecond claſs or order.*

THE EXTERNAL PARTS.

OF the water Scorpion which I occaſionally mentioned in the general enumeration of inſects, I have not ſeen more than two kinds. Theſe I ſhall now ſeparately deſcribe with figures, to illuſtrate the deſcription. The firſt, which is the ſmalleſt and moſt common of the two, is, like the greateſt part of the other more perfect inſects, divided into a head, a thorax, and an abdomen. In the head are placed the eyes, and under theſe is the mouth, which is of a round form, Tab. III. fig. IV. *a*. The head is of a pale red colour, and of a very hard and firm texture. The eyes are hexagonal and reticular. The ſting which lies in the mouth, as in a ſheath, is hollow, and of a bright red colour. In the upper part of the thorax, which reſembles the head both in colour and texture, we find four wings, and in the lower part as many legs, beſides two claws placed forward towards the head. The upper wings *b b* are of the ſame colour with the thorax; and it is remarkable, that the fore parts of theſe, by which they are joined to the ſhoulder blades, are of a ſtronger and firmer texture than the hinder parts, which are in a manner membranaceous, and full of delicate veſſels. Theſe upper wings are inſerted ſo cloſe to the lower pair, and cover them all over ſo exactly, that at firſt ſight no one would imagine the inſect had two pair. This diſpoſition of the wings preſerves the under pair from getting any wet, though the creature ſhould remain a whole day under water. Theſe under wings are of a pale colour *c c*, and of a membranaceous texture, with little yellow and red veſſels or pulmonary tubes moſt elegantly diſtributed through them. The upper part of the abdomen, which theſe wings cover, is of a deep and clear red colour, like vermilion, and is thick ſet with hair, ſo as to afford a very agreeable ſight. The legs have ſeveral joints, and each ends in two claws *dddd*. Theſe are almoſt of the ſame ſhape with thoſe of the land Scorpions *e e*, only they have no forceps or pincers; but the firſt point is ſo flexible, and the inſect has ſuch a command of it, that it ſerves the ſame purpoſe. The abdomen, whoſe ſhape has been already deſcribed, is underneath of a pale colour, and terminates in a forked tail, which when opened, is exactly like the figure I have here given of it *f*. The thorax and abdomen of this inſect are ſo unuſually flat and thin, that one would be apt to ſuſpect nothing was contained within them †.

There is nothing more remarkable in this inſect, than that it conſtantly appears covered with a prodigious number of nits of different ſorts and ſizes, though perhaps we may with more reaſon conſider them as ſo many little creatures, which live and grow by ſucking the Scorpion's blood. Theſe are ſomewhat of an oblong figure, approaching to round, and have a ſhining, and as it were bloated ſurface, without any of the rings obſervable in moſt inſects. The neck is oblong and ſhaped like a pear, with the ſmall end ſticking in the Scorpion's body. The colour of this inſect is a mean between that of vermilion and purple; and when it is pretty well grown, there appears within it an elegant tranſparent ſpot or particle, Tab. III. fig. IV. *g*.

This ſpot or particle induced me to conſider with more attention this minute and hitherto unregarded inſect, and even to undertake the diſſection of it. But who would imagine that on this examination it ſhould prove a perfect and ſurpriſing inſect? This is however a certain fact: and thus in that infinite variety of works, by means of which God is pleaſed to make himſelf known to us, we ever meet with new matter of admiration and aſtoniſhment.

This little creature being extracted from the ſhell that covered it, looks like a young Spider before it has left its egg. On the fore part is the head, fig. V. *a*, and on its head are the eyes *b*: under the eyes are placed its little legs elegantly coiled and folded *c c*; but they appear much more diſtinctly on turning the inſect on its back *d d*; and in this ſituation alſo it beſt appears with what art theſe legs are laid up in the ſhell, and all over covered with hair. The colour of this little creature is, as I already obſerved, a mean between that of vermilion and purple; and this colour ſhews itſelf through the coat or ſhell, which is tranſparent. I cannot determine to what ſpecies of inſects this is to be referred; nor can I ſay to what ſize it grows, or by what kind of creature it is thus depoſited on the water Scorpion in the form of an egg, there to receive life and growth. Nevertheleſs, I cannot but look on the diſcovery I have made as very intereſting, ſince it proves that there are in the nature of things eggs which acquire a ſenſible growth by an entraneous nouriſhment, unleſs perhaps ſome naturaliſt ſhould chooſe to conſider this as a complete inſect, rather than as an egg: nor ſhall I ſtrenuouſly oppoſe this opinion, ſeeing that in all caſes the egg is in reality no other than the inſect itſelf, which remains in that ſtate till it has acquired ſtrength ſufficient to break its priſon, and live without ſuch a covering.

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* The characters of the water Scorpion according to the latter ſyſtems are theſe: the trunk is turned in under the body, the antennæ or horns form a kind of claws like thoſe of cruſtaceous animals; the wings are four, and they are placed croſs-wiſe; and the legs are four. Linnæus connects the Cimeæ Aquatilis with this, and gives to the genus he thus forms the name Hepa.

† There is not perhaps in all the animal creation ſo outrageous or fierce a creature againſt thoſe weaker than itſelf as the water Scorpion. It deſtoys, like the Wolf among Sheep, twenty times as many as its hunger requires. I have ſeen one of theſe when put into a baſon of water, in which were thirty or forty of the Worms of the middle Libella, which are at leaſt as large as itſelf, deſtroy them all in a few minutes: he gets on their backs, and pierces his trunk through their body.

THE INTERNAL PARTS.

AMONG the internal parts of the water Scorpion, the organs of generation ſeem to be thoſe which beſt deſerve our attention, and which I have accordingly moſt attentively examined. The contents of the ſtomach and inteſtines were of a green colour, but thoſe viſcera when emptied appear of a tranſparent white, with here and there ſome tranſparent glandules of the ſame colour. Behind the pylorus are ſome varicous or knotty veſſels. The abdomen is all over covered alſo with particles of fat of a moſt bright white, which look as if they were divided into many appendages of the nature of the inteſtina cæca.

The number of pulmonary tubes is here very conſiderable, compared with that which is ſeen in the generality of other inſects. The larger branches of theſe tubes are of a yellowiſh colour, and the ſmaller of a ſilver white. Their openings lie under the wings on each ſide of the abdomen. The breaſt contains two air bladders. The ſpinal marrow conſiſts of very few joints.

The parts of the male ſubſervient to generation appear of a moſt delicate and exquiſite contrivance, ſo as to deſerve our moſt ſpecial notice; and the diſſection of them took me up ſo much time and attention, that in taking drawings of them I at firſt overlooked the penis. This is placed backwards near the inſect's anus, where there are ſeveral other parts worth examining. The root or nervous body of the penis, Tab. III. fig. VI. *a*, which is of a white colour, lies a little higher up in the abdomen, I have repreſented it here as it appears when taken out of the body. This root of the penis, after having made many ſerpentine turns, divides into four tubes, two of which conſtitute the vaſa deferentia, whilſt the other two perform the office of the veſiculæ ſeminales in other animals, and open into the cavity of the root of the penis, where they diſcharge the matter prepared by them. I have given an exact drawing of the vaſa deferentia; one of them I have repreſented as it appears moſt curiouſly convoluted in its natural ſtate *b*; the other as it looks when drawn out *c*. Theſe vaſa deferentia are conſiderably wide and ſpacious, but not equal to the veſiculæ ſeminales. It is probable theſe veſſels are adapted by nature to ſecrete a ſeminal matter different from that prepared by the teſticles; for they are largely ſupplied with glandules to anſwer that purpoſe, and conſiſt of a conſiderably thick and ſpongy ſubſtance. As the vaſa deferentia approach the teſticles, they grow leſs and leſs by degrees, ſo as to form two ſlender tubes *d d*, and this portion of them alone ſeems to claim the name of vaſa deferentia, as they do nothing but convey the ſeed from the teſticles: theſe teſticles conſiſt each of five diſtinct bodies, ſeparated on all ſides, oblong, white and glandulous *e e*, with which are united as many ſeminal veſſels twiſted and coiled one over another very elegantly, and in a great variety of directions *f f*. I have repreſented one of them as it appears when ſeparated from the reſt, and extended *g*. The veſiculæ ſeminales are ſomewhat ſhorter *h h*, but they are a little wider than the vaſa deferentia. The former contain an aqueous ſeminal matter, which in the teſticulary veſſels, the glandules of the teſticles, and even the vaſa deferentia themſelves appear of a ſhining white. From this we may conclude that the mechaniſm of theſe genital parts reſembles greatly that of the ſame organs in the Rhinoceros Beetle, which I ſhall hereafter deſcribe. Indeed in reſpect to the vaſa deferentia, the teſticulary veſſels, and the veſiculæ ſeminales, they are not unlike thoſe of the human ſpecies; and this reſemblance is very worthy our notice, in order to diſcover the general analogy between animals by a careful compariſon of their organs, as exhibited to us in accurate diſſections.

Among the parts of the female ſubſervient to generation, the moſt conſpicuous is a ſurprizing kind of ovary, divided on each ſide into five oviducts, one of which I ſhall here repreſent, and in part the reſt being ſimilar, fig. VII. *a a*. The eggs contained in theſe oviducts are of ſo curious a ſtructure, and placed with ſo much art, wiſdom and judgment, that I muſt own I never met with any thing contrived more nicely, or more elegantly diſpoſed. That this contrivance and diſpoſition may appear the more diſtinctly, I ſhall firſt deſcribe the egg itſelf, which in ſhape greatly reſembles the ſeed of the carduus benedictus. This egg is a little oblong, of a yellow colour, with its lower ſurface ſomewhat convex, fig. VIII. *a*. The edges of the upper ſurface are elegantly adorned with ſeven ſlender branches, not unlike ſtiff briſtles very red at the points *b*, and white in the middle *e*, ſo as to afford a very entertaining appearance. That theſe briſtles may be in no danger of creating confuſion in the ovary, or of wounding it, or the eggs, or receiving themſelves any damage by bending, the briſtles of the firſt egg, or that which is next to the aperture of the ovary, lie flat againſt the edges of the ſecond egg, ſo as to form a kind of bed for the lower and convex ſurface of it *c*. The third *d* and all the other eggs are orderly placed in the ſame manner, ſo as to afford ample matter for admiring and adoring the all-ſeeing Architect, who ſo wiſely formed and diſpoſed them.

Theſe water Scorpions live in the water all the day, out of which they riſe about the duſk of evening into the air, and ſo flying from place to place often betake themſelves in queſt of food to other waters. This is always their courſe when the ditches in which they inhabit, come to be dried up. This affords us a ſatisfactory reaſon for the great number of inſects that immediately appear in the ſmalleſt collections of water, ſince they may very well get thither when it is dark; ſo that the opinion which aſcribes to putrefaction the power of forming inſects, muſt by this inſtance of the water Scorpion's nocturnal tranſmigrations appear more and more frivolous and unneceſſary. I have in fact been told by a perſon who took great delight in fiſhing, that he has found the eggs of ſome kinds of Fiſh ſticking to the wings of Ducks, who by this means he with great reaſon imagined might ſerve to repleniſh the waters on the top of the higheſt mountains with the inſects proper to that element. The Nymph of the water Scorpion remains in the ſame place where it was produced, till the wings are full grown, when ſhe immediately ſallies forth in ſearch of a companion of the other ſex, with whom ſhe may carry on the great buſineſs of propagation, and multiply the ſpecies.

The Water Scorpions of the larger ſpecies differ but little from the ſmaller, which I have hitherto deſcribed. The body of the larger kind, Tab. III. fig. IX. *a*, is much longer and ſharper than that of the other; and its limbs are more diſtinct and conſpicuous. It is alſo of a paler colour, ſomewhat more gray, but inclining to red. As to the claws in this ſpecies there is in them ſomething very remarkable; the joints from which they ſpring are furniſhed each with two ſharp proceſſes *b b*, in order to receive, and as it were ſheath theſe ſharp claws when bent againſt them. The legs alſo are much longer, and are made like ſtiff and ſlender briſtles *c c*; but the membranous extremities and ornaments *d* of the wings differ greatly. I have not examined the internal parts of this ſpecies.

The natural hiſtory of the inſect called the Hemerobios, Ephemerus, or Diaria; extracted from J. Swammerdam's account of it, formerly printed in Dutch under the title of, The Life of the Ephemerus.

WE ſhall leave out in this extract all the pious meditations and religious ſentiments with which the original is ſo liberally furniſhed, as they would ſwell this work into too large a bulk, and do not properly belong to the deſign of it as a natural hiſtory. The author publiſhed at that time his obſervations on that ſurpriſing inſect, to give us wretched mortals a lively image of the ſhortneſs of this preſent life, and thereby to induce us by the help of frequent admonitions to aſpire to a better: and we hope we cannot in juſtice be accuſed of defeating his well-meant labours by abridging them in this manner, ſeeing his book, which he himſelf publiſhed, is ready to be had by any one that chuſes to read every thing he has ſaid on this ſubject. It contains alſo a great number of Dutch ſentences in verſe, and in proſe, of which it would be almoſt impoſſible to give a proper verſion fit to appear in public; and to interrupt the work with Dutch quotations, would be ſpoiling the regularity of the work. That the illuſtrious Thevenot, whom Swammerdam himſelf firſt charged with the edition of this work, intended to proceed in the ſame manner, appears very plainly from a French tranſlation of the natural hiſtory of the French Ephemerus, which has fallen into our hands amongſt other manuſcripts relating to this ſubject. We ſhall therefore proceed in this deſign of giving the reader all that relates to its hiſtory, and nothing more, without any further apology.

CHAP. I.

The Ephemerus is produced from an egg *.

THIS inſect, Tab. XIII. fig. xv. has four wings, two little antennæ or horns, ſix legs, and a very long and hairy tail; it lives at the utmoſt but five hours. This ſurpriſing creature appears every year for three day ſucceſſively fluttering on the ſurface of the water, at the mouths of the Rhine, the Meuſe, the Wael, the Leck and the Yſel, about the feaſt of St. Olophius and St. John; but this continued appearance is kept up by a ſucceſſion of them, for thoſe which begin to live and flutter towards the noon of the firſt day, are dead before night, and the ſame happens the ſecond and third days; which being expired, no more of them are to be ſeen till the returning year again renews this three days wonderful ſight.

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* The Ephemerus, for ſo it is the eſtabliſhed cuſtom now to write the word, conſtitutes a diſtinct genus among the four-winged Flies. The characters are, that there are two large prominences for the eyes on the upper part of the head; that the tail is furniſhed with ſome briſtly hairs, and the antennæ are ſhort. There are ſeveral ſpecies of this genus of different ſizes.

At this time the female of the Ephemerus, fig. VIII. after having thrown off her coat or ſlough, iſſues from the water and diſcharges into it both her ovaries, Tab. XV. fig. III. But this is not done till ſhe has for ſome time fluttered upon the ſurface of the water in a very curious and ſurpriſing manner, beating it with her wings all the time.

It is at this time the female like a fiſh diſcharges her eggs, which the male, Tab. XIII. fig. XV. who firſt quits the water, and afterwards diveſts himſelf on the land of a very thin ſkin, fig. XIII. and XIV. invigorates by ejecting on them his melt or ſeminal milky ſubſtance.

I ſhall in the ſucceeding pages deſcribe in a full and accurate manner how this act of generation is performed, how theſe inſects riſe from the water, and how they free themſelves both in the water and on the land of their old ſkins.

The firſt time I obſerved this ſurpriſing inſect, was in the year 1661, on a branch of the Rhine running by Culenburg. But Clutius who has likewiſe written of thoſe inſects, ſays they are to be found at Aarnhem, Zutphen, on the canal called Vaart near Utrecht, at Rotterdam, and in many other places. Doctor de Mey, a moſt reverend and learned divine, has likewiſe given us an expreſs treatiſe on this ſubject, as appears by the appendix to Goedaert's hiſtorical obſervations. Nor has the obſervation of theſe inſects been confined to our times, ſome of the greateſt naturaliſts of antiquity have made mention of them, as appears by Pliny, Ariſtotle, Ælian, and others who have written on theſe ſubjects. We find this little creature deſcribed in their works by the name of the Hemerobion, Ephemerus, and Diaria, as appears by many paſſages in their works, as likewiſe by Augerius Clutius's work, publiſhed in the year 1634, of which I juſt now made mention.

The eggs of the female Ephemerus dropt into the water, and there impregnated by an effuſion of the male's ſperm, in the manner we have deſcribed, gradually ſink to the bottom. But this is effected in ſuch a manner, that the eggs are ſcattered over the muddy bottoms of rivers by the motion of the waters. The figure of the eggs themſelves does not a little contribute thereto, as they are of a plain convex ſhape, Tab. XV. fig. I. and are thereby the apter to diſperſe in their deſcent. This appears by placing a few of them on the point of a knife, and then letting them fall gently into water, for they immediately ſeparate of themſelves in a very curious manner.

It is hard to ſay, and God only, who gives theſe inſects life and motion, knows how long their eggs lie at the bottom of the waters where they are depoſited, and how long it is before the contained inſects break through the ſkin that ſurrounds them, and perform as it may be called their firſt moulting. It is not improbable that theſe things might be experimentally aſcertained by dredging for them at different ſeaſons, or keeping their eggs in a veſſel full of water with a ſufficient quantity of mud at the bottom. For the preſent we muſt be ſatisfied to obſerve that the eggs of the Ephemerus produce, after an unknown time, a little Worm with ſix legs. This is the creature fiſhermen call the bank-bait.

CHAP. II.

The egg of the Ephemerus produces a little Worm with ſix legs, called the bank-bait by fiſhermen.

ON ſearching the bottoms of waters frequented by the Ephemerus, ſome time after it has laid its eggs, we find a multitude of little Worms with ſix legs, which differ in nothing but ſize from thoſe that are more grown. But this is not to be found till a long time after the parent inſects have made their appearance, for the growth of this little inſect is ſo ſlow, that in the beginning of June in the year following, about which time the bait turns to an Ephemerus, they are ſcarce three quarters of a Dutch inch long, Tab. XIII. fig. I. which is but about the third part of the length of the full grown Worms, fig. III. that have complete wings, and are juſt upon the point of making uſe of them.

Beſides two kinds of Worms remarkably differing in bigneſs, a third is obſerved to be produced at the ſame time from the mud, fig. II. which is bigger than the leſſer kind by almoſt two thirds, and is a third part leſs than the largeſt kind. Nor is this difference between theſe Worms in reſpect to their various age, all we obſerve, for thoſe of the ſame age differ greatly both in length and thickneſs. When the largeſt kind of theſe Worms is about three thumbs breadth long, in the beginning of June, when they are about to begin to fly; the middle kind is not completely two long; and the ſmalleſt is ſcarce a thumb's breadth in length.

There is another remarkable difference between theſe Worms of the Ephemerus, which is, that the ſmalleſt kind, fig. I. not only is without wings, or thoſe prominences which cover the wings, but it does not even ſhew the leaſt ſigns or veſtiges of any ſuch part: whereas, on the contrary, in the other kinds of theſe Worms, the little ſheaths of the wings, fig. II. begin at that time to appear, and in the largeſt kind are as conſpicuous as poſſible, fig. III. reſembling a little flower, that increaſes by degrees, and is ready to break out of its cup.

CHAP. III.

Of the life of the Vermicle or Worm of the Ephemerus, when out of the egg; and of its food.

IT is very worthy of notice, that theſe Vermicles or Worms never, or but very rarely, are obſerved to ſwim at the bottom of the river, or even in the middle of the water. They can indeed ſwim very ſwiftly, and move and throw themſelves eaſily into ſerpentine windings in the water, whilſt their head is bent ſometimes up and ſometimes down; the reſt of the body advancing with the like twiſting convolution and ſerpentine motions. But, notwithſtanding they have this in their power, they are always found near the banks of rivers, and they live there in the moſt quiet parts. The more mud there is in the bottom, out of which they firſt riſe, the greater number of theſe Worms is uſually found. But you can very rarely catch them lying on the mud or adhering to it, but they live within the mud or clay itſelf in hollows made oblong and ſmooth. Theſe are bored, not obliquely or downwards, but always parallel to the horizon: therefore, Vander Kracht ſays right in Clutius, that theſe inſects live in ſeparate little cells.

As the Bees, therefore with wonderful and perhaps inimitable art form their habitations with wax; in like manner do the Worms of the Ephemerus make theſe hollow tubes, Tab. XIII. fig. v. *a*, or long holes for their reſidence, and bore them in the mud, in proportion to the bulk of their bodies. Hence, when theſe Worms are expelled out of their holes, ſo that they muſt creep on the plain or ſmooth bottom, which does not ſupport every part of their bodies, they immediately loſe their ability to go forward, though they are even ſurrounded with water, and are able to ſuſtain or bear themſelves up by ſwimming. This I have experienced, when I had drawn a great number of theſe Worms out of their holes, in order to diſſect them; they always fell on their backs, and, as if they were in a ſwoon, could not turn themſelves again: whereas, on the contrary, when they are in their little holes or burrows, they can creep very quickly backwards and forwards, and move themſelves every way as they have occaſion. I obſerve that it is common to all kinds of Worms which live in theſe kind of cells or holes to be able to move very quickly into their retreats, and when they are taken out of them, to faint as it were away. This I have obſerved in the Worms which live in hollow trees, and alſo in thoſe which are found in fruit, in the tubercles of the leaves, and in the galls or warts of plants. It is very worthy of obſervation, that the Coſſus or Worm of the great Beetle, whenever it is taken out of its houſe, covers its whole body with a web, by the help of which it forms a new hole for itſelf in the wood; for it could by no means pierce or make a hole, unleſs it were provided with ſome kind of ſtay or ſupport to lean againſt by preſſing its body in that part, and finding a due reſiſtance.

The bait or Worm of the Ephemerus is ſo weak when out of its hole or little tube, that if at any time it ceaſes to move, when ſwimming in the water, it immediately ſinks to the bottom in confuſion, and there lies on its back.

We are to remark further, that as ſoon as the Worms of the Ephemerus have iſſued out of their eggs, they prepare to build their cells or houſes, which we have obſerved are long and horizontal hollow tubes or caverns made in the clay or mud. But they make theſe tubes by degrees larger and larger, according to the ſize of the body, ſo that by this means the full grown Worms are always found in larger, Tab. XIII. fig. v. *a a*, the young ones in ſmaller tubes, *b b*.

The all-wiſe Creator has given them parts appropriated to this purpoſe; their two fore legs are formed, in ſome meaſure, as they are in the Moles and Mole Crickets. Theſe Worms have jaws likewiſe, which are provided with two teeth ſomewhat like the forceps or claws of crabs, and theſe ſerve very well to aſſiſt in making thoſe holes in the mud.

Hence you will immediately ſee them piercing or boring, when they are thrown into a little mud mixed with water. If you do not give them a ſufficient quantity of the mud, they will nevertheleſs continue to undermine what they have, at one time hiding their head, and at another their body, and afterwards their tail, attempting to prepare new cells.

The fiſhermen ſay, they are certain from experience that theſe Worms, when the water ſinks from the brink or edge of the river, always bore holes through the mud into a lower and deeper part, and that they likewiſe go to higher places, when the water riſes. This, I think, they are under a neceſſity of doing, ſince they have ſeveral air-pipes in their tracheæ, by the help of which they frequently draw new air, which is neceſſary to their life. This they could not do, if they were confined at too great a depth when the water roſe higher.

I have often obſerved that when they were drawn out of their cells and put on the wet ſand, they have choſe rather to creep out of the water, than go to the bottom under the ſand. This might poſſibly be owing to the want of mud, and the warmth of the water, which is probably injurious to them.

As to the food of theſe creatures, it is very difficultly diſcovered, unleſs by the diſſection of them, which taught me that they live on clay or mud only. Whenever you open them, you will always find mud both in the ſtomach and in the ſmall and great guts. Theſe Worms are therefore in this reſpect like the Moth, which feeds on the ſame ſubſtance of which it makes its habitation.

CHAP. IV.

How long the Vermicle or Worm of the Ephemerus is winged; why it is called the eſca or bait; and how long it lives.

HAVING conſidered the egg, the Worm, and the food of the Ephemerus, the next thing is to ſee for what ſpace of time this Worm is fed or nouriſhed: and though it ſeems a thing impracticable to determine how long any creature which lives in the earth under water is in feeding, yet this problem may be ſolved by conſidering the different bigneſs of thoſe Worms which I have beforementioned. Since the ſmalleſt kinds of them, when fed for one year, in which time the largeſt kind prepares to fly, is three quarters of a thumb's breadth in length, and the middle ſpecies is then only one half; it follows, that every Worm is feeding three years before it becomes fit to undergo its change, becauſe the largeſt kind of Worms which begin this change, are two thumbs and a half long.

The largeſt day Worms when fully nouriſhed or fed, regularly go out of their cells into the water, and thence afterwards riſe into the air, as I ſhall explain hereafter. As every creature has its enemy, theſe have many; the fiſh perſecute them immediately after they go into the water, in order to undergo their change; and when this is accompliſhed and they riſe out of the water into the air, the birds immediately hunt after and prey on them. This has been obſerved by the ſailors, fiſhermen, and others, who live near the Rhine, ſo that they learned from hence to uſe thoſe little creatures as a bait to catch fiſh. And hence it is that theſe Worms are called by the name of bait or bank-bait, near the village of Duerſtede, Culenburg, and in other places. This has likewiſe been the reaſon that theſe creatures, when they afterwards began to fly, have been called by the name of the flying bait. But this creature is called Haft at Rotterdam, Schoonhoven, and Dordrecht, the moſt ancient city in Holland, as ſoon as it becomes capable of flying. Hence has ariſen the common proverb among the Dutch, "Het iſſer zoo dicht als haft," to indicate a very numerous multitude, becauſe theſe little creatures at the times of their change, fly ſo thick together in ſwarms, that thay can no more be counted than the falling flakes of ſnow.

Theſe Worms afford a very good bait for fiſhing at any time of the year, if the weather be favourable for that purpoſe; for ſince they live three years in the mud before they are changed in ſo wonderful a manner, like Silk-worms, into flying creatures, they may be eaſily taken out of the banks at any time of the year for the ſportman's purpoſe. But this cannot be conveniently done when the waters have riſen high, for it is then neceſſary one ſhould go naked into the water, which I have ſometimes got done, that I might have an opportunity of inveſtigating the nature and diſpoſition of theſe inſects, and be able to examine anatomically the internal parts. When the fiſhermen uſe this Worm, they fix the hook in the head, which is its hardeſt and moſt firm part. And as it is very long-lived, by the perpetual motion it makes in the water, it becomes a very proper bait to allure the fiſh to ſwallow the inſidious hook.

How very durable the lives of theſe Worms are I could thus form a judgment: I have ſometimes pierced one of them with a little needle, in order to dry and preſerve it when dead, but it has been ſtill living the day after, though it had been a whole night in a little veſſel of urine, into which I had thrown it in order to kill it. But however tenacious they are of life, when they are taken out of their cells, and put into water mixed with clay they cannot live more than two days. Therefore, whoever deſires to keep theſe Worms alive ought to put them in nothing elſe but moiſt ſand or wet clay. By this means I have known the largeſt live four days, and the ſmaller eight. But when they are all covered with water, they cannot by any means continue alive, for they muſt have air.

If any one deſires to ſend theſe Worms abroad, the beſt method is to tie together ſome tubes made of the largeſt bull-ruſhes, and to put the Worms into them; for otherwiſe they can ſcarce be ſent well, becauſe by running up and down at random, they hurt each other. By this method they may be likewiſe eaſily carried to other rivers, as fiſh are carried from one place to another.

CHAP. V.

Deſcribes the external parts of the Eſca or bait, its colour, and the difference in its manners and diſpoſition.

HAVING accurately examined the Worm of the Ephemerus, I obſerve that it is divided into fourteen annular diviſions; the firſt conſtitutes the head; the three ſubſequent the thorax; and the other ten the belly, with the tail annexed.

In the head, Tab. XIII. fig. IV. *a*, the eyes are very conſpicuous, being inveſted with a uniform and ſmooth coat, and covered on either ſide with briſtly hairs. When the Worm is on the point of changing its old skin, we obſerve this ſmooth coat to part or ſeparate by degrees from its eyes, and the eyes when the little creature begins to fly, appear reticular as they are in Flies. A little lower under the eyes are ſeen two tender horns *b b*, terminating in ſharp points, and articulated or divided into joints. Under theſe are ſeen a pair of dentated forceps or jaws *c*, conſtituting the creature's mouth. About the origin of theſe jaws, underneath, ſeveral more hairy and membranous little parts appear, which are ſomewhat like theſe that we obſerve in Crabs and Shrimps.

To the firſt ring of the thorax are fixed the two fore legs *d*, the ſtructure whereof, and the joints of which they conſiſt, merit great notice. The ſtructure is in ſome meaſure like that obſerved in creatures that borrow under the earth. Hence the ſtrongeſt motion which theſe legs have is outward, by which they can the more conveniently pierce and remove the earth, like Moles in making their cells.

Every leg is compoſed of four joints, and terminated by a ſingle claw. The firſt joint is affixed to the breaſt; the next to this is ſomewhat crooked, as is likewiſe the third, which conſiſts of a matter ſomewhat more bony and horny than the others, and is armed with prominent brown red little points like teeth, and ſurrounded laterally with numerous hairs. The fourth joint is very ſmall, and is armed with a ſmall claw. The muſcles likewiſe, and their inſertions may be ſeen very diſtinctly here, by the help of which the bony joints are beautifully moved.

To the ſecond diviſion of the thorax, which is the third ring of the body, and properly conſtitutes the loins, and is covered both above and below with a ſhield of a horny little bone, is annexed a ſecond pair of legs, Tab. XIII. fig. IV. *d*, which conſiſts of five joints and one claw; and are here and there furniſhed alſo with hairs. Somewhat behind theſe, the follicles or little ſheaths *e*, wherein the firſt pair of wings are concealed, are ſeen on each ſide. Theſe ſheaths are here and there interwoven with air veſſels, which appear on their external ſurface, like common little veins or nerves. When the Worm is juſt going to caſt its skin, the internal or under wings are folded in a wonderful and elegant manner, and appear through their external coats or follicles.

There apperrs on the third ring of the thorax, which is the fourth of the body, the inſertion of a ſecond pair of wings, which are much leſs than the firſt pair, and are wholly covered by them. This firſt pair likewiſe partly covers the hindermoſt or laſt pair of legs, which conſiſt like the others of five joints and one claw, and are adorned with numerous hairs.

The firſt ring of the abdomen, or the fifth annular inciſion of the body, is all even and ſmooth, nor is it joined to the legs, the wings, or any other part. To the ſix following rings are affixed very beautiful branchiæ or gills *f f*, perpetually fluttering, and beating up and down with a tremulous motion. By the help of theſe Clutius erroneouſly thinks the Worm ſwims; but theſe parts are undoubtedly the branchiæ or gills of the creature. In Lobſters, Crabs, and Cuttle-fiſh, which approach in many reſpects to the ſtructure of inſects, we conſtantly find theſe little parts framed and ſituated in the ſame manner, with this difference only, that in Crabs and Lobſters they are encloſed in a hard ſhield, wherewith the back is covered, but in theſe as well as in the Cuttle-fiſh, they are ſituated higher on the body than in the Ephemerus. In the figure of this Worm given by Crachtius, twelve gills are expreſſed on each ſide. This error ſeems to have ariſen from a wrong view, ſince there are only ſix on each ſide, the whole only make twelve.

The eighth and ninth diviſions of the belly, which conſtitute the twelfth and thirteenth rings of the body, are all even and ſmooth. Theſe are ſucceeded by the tenth or laſt, that is, the fourteenth diviſion of the body. This is adorned with three hairy and briſtly tails, Tab. XIII. fig. IV. *g*, to which are alſo added two crooked appendages, which are not ſo remarkable in the females; but in the males they are likewiſe accompanied with ſome other little appendages underneath.

As to the colour of theſe Worms, the ſmalleſt appear of a pale blue with a tinge of green. This, however, cannot be properly ſaid to belong to the creature itſelf, but is rather owing to the viſcera which are ſeen through. The eyes of all theſe Worms are of a blackiſh brown colour, and the back is ſpeckled with pale brown ſpots, which increaſe by degrees with its age. The mouth is paliſh, and is furniſhed with rediſh brown teeth; of this colour are alſo the forceps or jaws which are beneath them, having two teeth and conſtituting part of the mouth. The horny parts and the claws of the legs are likewiſe of a reddiſh brown.

The exuberant wings inſenſibly change their pale colour into a yellowiſh one, which, in proceſs of time becomes a bright blue, and at length a brown black. The whole body of the creature is by little and little ſtained with a pale yellow colour, and the blackiſh ſpots in the back, where it conſtitutes the upper part of the belly, are changed by degrees into a deeper colour.

The difference between theſe creatures with reſpect to their ſex is another point very worthy of notice. For the eyes, Tab. XIII. fig. IV. *a*, of the male, are twice as large as thoſe of the female, fig. III. but the body of the male is commonly much leſs than that of the female, which is the caſe in inſects in general, as far as I have obſerved; and it ſeems to be ordered very prudently ſo by nature, or more properly, by the very wiſe Creator, in order to give the due room to a large number of eggs. The male in this ſpecies has the tail very long, and beſides he has three or four other appendages, placed partly on the ſides, partly under them, which can ſcarce be diſtinguiſhed in the females. The male that I exhibit in fig. IV. of Tab. XIII. is the largeſt of all I have ſeen, though much larger females may be found.

As to the diſpoſition and manner of this inſect, I can ſay little from my own obſervation: but one thing I may venture to affirm, that among all the ſpecies of inſects, I never ſaw any one more mild, gentle, or innocent. For in whatever manner it is treated, it is always calm and peaceful, and when left to itſelf, it immediately goes to work, and begins to dig a cell for its habitation. I have obſerved indeed in the ſmalleſt ſpecies, that when rudely handled, it bends its head towards its breaſt, and makes itſelf ſomewhat ſtiffer. Of all the actions of this creature none is more admirable than the agitation of the branchiæ or gills, Tab. XIII. fig. IV. which adhere to either ſide of its body, for theſe are ſo orderly, diſtinctly, and continually ſhook and vibrated, that the mind, when intent on theſe incomprehenſible movements, is filled with aſtoniſhment.

CHAP. VI.

The anatomy of the internal parts of the Ephemerus.

HAVING briefly deſcribed the egg, Worm, food, age, external parts and diſpoſition, ſo far as I obſerved, of our little inſect, what ſhould naturally come next into conſideration would be to explain its change. But as this is performed ſo haſtily, that it conſiſts almoſt only in the caſting of two coats or ſkins, and the diſplaying or unfolding of ſome limbs and parts before covered, in order to underſtand the difference between the ſwimming Worm and this flying inſect the more diſtinctly, I think it better to deſcribe its internal parts firſt; and the rather, becauſe all theſe parts under both forms of this creature may be in this account taken notice of.

Though in deſcribing the internal parts of the Eſca or Worm of the Ephemerus, I ſhall enter upon them in a method not yet obſerved by any perſon that I know of; yet, according to the example of Clutius, I ſhall not complain of the ſcarcity of books, treating of this ſubject, nature herſelf being the beſt interpreter of all her works: books are to be admitted no further than as they expreſs the truth of what ſhe repreſents to our ſenſes. I am therefore in pain for thoſe, who, relying on the experiments related by others, frame innumerable fictions, and therewith deceive their readers with themſelves. It cannot be poſſible that any perſon relying on his own underſtanding and judgment, ſhould, in ſuch a variety of experiments, follow the ſtraight path of truth, and with an unprejudiced and candid judgment paſs a juſt ſentence on the obſervations of others, eſpecially ſince we obſerve that the moſt certain experiments are obſtinately rejected by many, unleſs they correſpond with their own opinions or prejudices. I ſhall build only on what I have ſeen, though I may in this perhaps be blamed; for that not having had a ſufficient number of the Worms, I have not been able to bring their diſſection to the utmoſt perfection, ſo that in this reſpect I cannot every where ſatisfy my own inquiries. But I have long ſince learned, that the works of God are as inexhauſtible and incomprehenſible as his own perfect nature; ſo that theſe things ought not to be contemplated by us for any other purpoſe, than that we ſhould be humbled by a due conſciouſneſs of our ignorance, and be obliged to adore their Creator, and love him truly.

In order to make the obſervations I have to offer as clear as poſſible, I ſhall at the ſame time declare the method, which I made uſe of in the year 1670, to determine the true diſſection of the ſeveral parts; for it is by no means my intention to deceive either myſelf or others. Before I proceed to the deſcription of the internal parts, I ſhall, in order to aſſiſt the memory, briefly enumerate what parts are obſervable outwardly in the Worm of the Ephemerus, as alſo what inward parts I found in the male, and what in the female.

The external parts of the Worm are the head, ſkull, horns, eyes, teeth, mouth and tongue, together with their hairy membranes, which are like thoſe in the Crab kind. The breaſt, legs, claws, wings, belly, and what appertains to it; the twelve upper branchiæ or gills, the ten lower oars that ſerve the creature for ſwimming, the tails with their appendages, and laſtly, the apertures of the pulmonary tubes under the breaſt.

The inward parts of the male are, beſides the blood and membranes, muſcles and fat, the ſtomach and inteſtines, the pulmonary tubes, the heart, the ſpinal marrow, and the ſpermatic veſſels.

In the female I find all the parts juſt recited, with only this difference, that inſtead of ſpermatic veſſels an ovary is here ſeen, ſurrounded with ſmall membranes, which are interwoven with very many pulmonary tubes.

As I have not yet accurately examined the internal parts of the head and eyes, for want of a ſufficient number of Worms and Flies, I ſhall not ſay much concerning them, nor of the parts of the thorax, the latter being for the moſt part filled with the muſcles of the legs and wings.

If the male Worm of the Ephemerus, which it is eaſy to diſtinguiſh from the bigneſs of its eyes, be firſt laid on its back on a ſmall piece of a fir board, and then faſtened with the ſmalleſt needles that can be had on black paper or a ſmall piece of linen, we immediately ſee a thin and watry humour diſtilling out of the wounds in the skin, which is the real blood of this inſect. And yet it is not red, as is the caſe in Earth-worms, the blood of which, as well as that of quadrupedes, is tinged with that colour. I don't know a more proper inſtrument to open the ſkin than a fine and ſmall pair of ſciſſors, for little lancets, though never ſo ſharp, are not fit for this purpoſe, becauſe they always pull and tear the parts aſunder, and eſpecially if the membranes be not equally hard.

When the skin is after this gently and deliberately ſeparated with a fine ſharp-pointed pen-knife from the parts underneath, an interior very thin and membranous skin immediately appears. If this be afterwards cautiouſly removed, the muſcles of the belly preſent themſelves to view, as well thoſe which extend from one diviſion to another, with ſtraight fibres of the body, as thoſe which are protended obliquely and acroſs: other muſcles are alſo ſeen, which ſerve to move the branchiæ or gills. The coat or other ſkin is likewiſe fibrous, and ſeems to be joined to the muſcles before deſcribed.

After the muſcles appears a very fine and delicate membrane affixed to them, which I take to be the peritonæum. About and under this appears a quantity of fat, conſiſting of ſmall, fine, and white veſicles, which contain a real fat in the form of fluid oyl. Whoever views theſe veſicles without a microſcope, may naturally take them for the fat itſelf, whereas they are only thin and very tender bags containing it, as is the caſe in man and other animals. This will be very plain, if theſe pingueferous bags, which are of equal bigneſs, be viewed with a microſcope. The younger the creatures are, the more conſpicuouſly they exhibit this fat, ſince it then lies here and there diſperſed on the membranes, nor is it heaped together ſo thick as in the older ones.

After obſerving theſe, we come to the ſtomach, Tab. XV. fig. v. and to the inteſtines which are continued from it. Here is preſented to view the œſophagus, or otherwiſe the tube of the upper orifice of the ſtomach, which deſcends like a fine filament from the mouth or jaws through the back and thorax, and enters and is connected with the upper part of the ſtomach. Where this little tube is connected with the ſtomach, it becomes narrower and cloſer *a*, as may be ſeen about the lower part of the ſtomach, or towards its lower orifice *b*.

Though the ſtomach *c* conſiſts of divers parts, yet it ſeems throughout to be formed of a thin and tender membrane, corrugated on the inſide, and full of reticulated or net-like folds or plaits. On the outſide it exhibits a ſmooth ſurface, and is expanded regularly, eſpecially when it is ſwollen or filled with food, or if it be artificially diſtended with air, by the help of a ſmall glaſs tube. No veins or arteries are ſeen in it, for the blood of theſe inſects is of a watry colour, and therefore does not diſtinguiſh the veſſels containing it from the other parts; this is the reaſon that theſe creatures were called exanguious or without blood.

It is however obſerved, that the ſtomach *c* is provided with many tubes which reſemble blood-veſſels. But if they be well examined with a microſcope, it appears they are branches of the pulmonary pipes, Tab. XIV. fig. 1. *a a*, for they give little air canals, not only to the ſtomach but to all the external as well as internal parts of the body. Hence, even the legs and their claws have air tubes. The inteſtines, Tab. XV. fig. v. joined to the under part of the ſtomach, appear to be threefold in regard to their form and ſtructure: there appear, 1ſt, the crooked or ſmall gut *d d*; then 2d, the colon *e*; and laſt, the rectum *f*. Within the ſmall gut, ſomewhat further towards the hinder parts, are obſerved ſome lunated wrinkles, not unlike thoſe little vales of the ſmall guts in the human ſpecies, which the anatomiſts call annulares. A little below where the colon *e*, riſes out of the former, are ſeen ſeveral oblong furrows, which are very fine in the living creature, and reſemble ſo many long muſcular villi or hairy parts extended in the cavity of the inteſtine, correſponding in ſome meaſure with the echinus, which is a natural part of the ſtomach of quadrupedes: then the rectum follows this, and is folded very elegantly, until it terminates at the external parts of the body with a pretty large orifice, through which the fœces are diſcharged.

The ſtomach *c* is ſituated between the fourth and fifth annular diviſions of the body, and there, together with the ſmall gut, takes up the whole foremoſt region of the belly, that is, the 6, 7, 8, 9, 10, and 11th inciſions. But the other three diviſions, namely, the 12, 13, and 14th, contains the inteſtinum rectum et craſſum, or the thick and ſtraight gut. As the ſtomach has a great number of ſmall air-tubes, ſo the inteſtines have alſo the ſame, but moſt eſpecially the rectum, which has vaſt numbers of them, where its two muſcles, Tab. XV. fig. I. *i i*, which force out the excrements are ſituated.

As the food of this Worm is mud or clay, the ſtomach and inteſtines are uſually found filled with it. This mud is found almoſt always to ſhew itſelf both through the ſtomach and inteſtines, and indeed through the whole body, but more particularly ſo in the back. And hence, as the body is ſo tranſparent, it follows, that the Worm does not appear to have always the ſame colour, ſince the mud is ſometimes paler, ſometimes greener, and ſometimes more fleſh-coloured, as it is more or leſs digeſted or changed in the ſtomach and bowels.

As the time approaches when the Worm is to undergo its final change, and put on the form of a flying inſect, no more mud is found in its inteſtines. The ſame likewiſe happens in the Coſſi or Worms of Beetles, and in Bee-Worms and Silk-Worms, as alſo in other inſects, for they all at that time become clear as chryſtal. Some inſects are all their life-time tranſparent, ſo that their veſſels, the viſcera, and their motions may be at all times ſeen and diſtinguiſhed in the body.

Of the inward parts of the Ephemerus, the moſt worthy of notice are the pulmonary tube, and the aſpera arteria tracheæ or windpipe, Tab. XIV. fig. I. *a a*, as it is called in birds and quadrupedes, and in the human ſpecies. This tracheæ does not proceed in the preſent inſect from a ſimple trunk, as in man or other animals, but conſiſts of two principal trunks, which are placed on each ſide of the body running in a ſerpentine manner, nor are they diſtributed in the breaſt only as in us, but throughout the head, belly, legs and wings, ſo that by their means the ſtomach and inteſtines, together with the muſcles and nerves, are all ſupplied with air. As this appears to us a very wonderful thing, becauſe we do not underſtand the reaſon of it, it moſt evidently teaches us how devoutly and religiouſly we ought to adore God in all his prodigious works, which are equally inexhauſtible and impenetrable.

The pulmonary tubes * in this inſect, as well as in the others that I have examined, conſiſt of innumerable little rigid and curled parts, which are artificially joined together like twiſted or ſpiral rings, and are ſo cloſely linked to each other by the help of their tender and delicate inveſting membranes, that they can eaſily retain the air, and convey it to all parts of the body.

When the Worm changes its skin, I ſhould imagine that theſe pulmonary pipes likewiſe caſt their covering, though I have never hitherto been able to ſee it; for at the time when I began theſe experiments no ſuch thing appeared to me. The change or caſting of the skin of theſe pipes is ſo remarkable in Silk-Worms, that it amazes the underſtanding; for in the very ſhort ſpace of time wherein that creature caſts its skin, ſome hundreds of theſe pulmonary pipes in the inſide of its body, caſt alſo their tender little skins, which are all compounded of ſuch twiſted rings.

The colour of theſe pulmonary tubes or pipes is like that of mother-of-pearl, but ſomewhat inclining to gray; but the more frequently the skin is changed, it becomes by degrees of a clearer and more tranſparent whiteneſs. They are therefore much whiter in the flying creatures than in the Worms which precede them. They are diſtributed through the whole body, in order to convey the air, which they carry as well to the internal as external parts of the inſect. Hence theſe two moſt conſiderable and remarkable tracheæ, Tab. XIV. fig. I. *a a*, which are placed in the Worm on each ſide of the body, diſtribute their ramifications and branching air-pipes all over it; that is, in the head towards the nerves and brain *b b*; in the thorax *c c* to the muſcles of the legs and wings; in the abdomen *d d d d* to the obliquely aſcending and ſtraight muſcles, as alſo to the ſpinal marrow *e e e*; and to the ſmall guts or ſeminal veſicles *f f f* of the male; to the hairy branchiæ or gills *g g*; to the ſtomach, Tab. XV. fig. V. *c*, and the inteſtines, Tab. XIV. fig. I. *h*; to the ſkin *i i i*; to the coat of the wings *k k*; to the ovary, Tab. XV. fig. I. *l l*: in the female alſo to the coat that inveſts the ovary *m m*; to the eggs themſelves. fig. VII. *n*, as is ſeen when they are taken out of the body, and even to the heart itſelf. Fig. IV. *o o. t t.*

I have found it a difficult matter to diſcover the external aperture of theſe pulmonary pipes, ſince they do not open into the mouth or throat, as in other creatures. For which reaſon the nearer they approach the head, the ſmaller they become, when it would be natural to ſuppoſe they would become larger and more capacious. At length, after repeated inveſtigations, I perſwade myſelf that I obſerved that the little apertures or entrances of theſe pipes opened underneath in the ſide of the breaſt; almoſt in the ſame manner as I afterwards diſcovered them alſo in Locuſts, in which laſt mentioned inſect theſe apertures may be eaſily ſeen. But as the Ephemerus lives in water and mud, therefore its tracheæ muſt be opened by narrower orifices, on which account it is more difficult to diſcover them.

From theſe experiments it appears moſt evident, why the Worms of the Ephemerus or Day-Fly, when the water of the river increaſes, riſe likewiſe higher, and go to other cells, for they very frequently want freſh air to breathe. And for the ſame reaſon, when the water is lower, they muſt be likewiſe found to deſcend deeper; for they would then become too dry, and their cells or habitations would be dried and ſhut up.

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* The doctrine of theſe pulmonary tubes in inſects has been confirmed by all ſucceeding obſervations: the latter authors only have changed the names of theſe veſſels, and their openings on the ſurface of the body. They call the tubes tracheæ, and the apertures on the ſurface of the body, which this author terms puncta reſpiratoria, they call ſtigmata. This laſt term, though more modern, is exceptionable; for ſtigmata is uſed in botany to expreſs the heads of the ſtyles in flowers, and pure philoſophy condemns this equivocal uſe of terms.

The pulmonary pipes hitherto deſcribed cannot, in any inſect, be examined better than in the Worms, when they have been dead ſome days, as their viſcera are then growing black; for then they exhibit a very beautiful appearance to the eyes, becauſe they are of the colour of mother of pearl, or ſilver when cleaned by boiling; alſo, as they conſiſt of a ſomewhat hard and firm ſubſtance, ſo that they do not ſoon putrefy: hence they alſo retain at that time their form and roundneſs.

If the breaſt and belly of theſe worms be viewed with a microſcope, the whole abdomen is ſeen to be interwoven with white ſilver-coloured veſſels. In order to diſcover whether there be really any air in theſe veſſels, they muſt be put into a little drop of water, and preſſed with the point of a needle, for thus the encloſed air will immediately ſhew itſelf. When theſe inſects are diſſected under water, and ſome of the pulmonary pipes are cut off with a fine pair of ſciſſors, they immediately riſe to the ſurface of the water; the ſame thing may be ſeen about their broken ramifications, the extremities of which are then carried upwards. In a Worm that has been dried, having been divided in the middle, theſe air-pipes are moſt eaſily diſcovered, becauſe they always in that caſe remain open from the force of their curled rings, though all the other parts grow perfectly hardened.

Amongſt the many things which may be obſerved concerning theſe pulmonary tubes, it is particularly worthy of notice that ſo great a number of them are diſtributed towards the branchiæ, Tab. XIV. fig. I, or gills, ſo that three principal branches *p p p* of the air-veſſels may be ſeen in thoſe which I have repreſented as cut off: the middle one of theſe branches is alway blackiſh *q q*, except in the centre of it, which is whitiſh and tranſparent; the other two run on either ſide of the middle black one, and diſtribute a large number of ſilver-coloured veſſels *g g g* through the branchiæ or gills. Theſe veſſels are not well diſtinguiſhed by their colour, becauſe the ſix branchiæ or gills, Tab. XIII. fig. IV. *f f*, through which they are conveyed from each ſide of the body, are white and very tranſparent. Under theſe, on each ſide, are obſerved five rowing fins, Tab. XIV. fig. I. *r r r r*, of a yellow colour, by the help of which the Worm ſwims.

I made during my diſſections ſome further obſervations on thoſe branchiæ and their veſſels, but as I do not know where the papers are, the obſervations have alſo entirely ſlipped out of my memory. Hence I am ignorant what uſe that feathered little part *s s* is of, which is ſeen under the firſt as yet entire pair, and whether it be likewiſe found about the other branchiæ or gills. Neither do I know the proper communication between theſe branchiæ and the air-pipes, Tab. XV. fig. IV. *o o*, between the latter and the heart *t t*. I cannot therefore ſay any thing more with certainty concerning them than what may be gathered from the figure. I omitted, to prevent confuſion, delineating in this all the air-pipes which are about the heart, having exhibited ſome of them only entire, and others cut off or broken *v v*.

Indeed, in my figures I have not always obſerved the proportional magnitude of the parts, ſince I looked upon that as a work of great labour and little uſe, and therefore I have not ſcrupled ſometimes to delineate one part larger than another. Beſides, I never intended to publiſh theſe experiments, without being firſt reviſed; and this I have afterwards thought the more neceſſary, becauſe from that time I acquired a greater knowledge of the parts of theſe inſects, and became more capable of aſcertaining their anatomy. I hope the benevolent reader will kindly pardon the imperfections of this work, which I muſt confeſs are innumerable; for what man is able to deſcribe, even with the uninterrupted labour of many years, all the miracles that are to be met with in this little inſect.

The heart, Tab. XV. fig. IV. *t t*, is found to be placed in the upper part of the body in the back, as it is in Silk Worms, Bee Worms, Coſſi, or Worms of Beetles, Caterpillars, and other inſects of that nature. It is ſomewhat protuberant *x x x x* in ſeveral places, and it is ſo in Silk Worms alſo, as has been obſerved by the diligent Malpighius. But this author does not ſeem to me, as far as I can learn from my own experiments, to have fairly from this drawn his concluſion that this inſect has more hearts than one. I have diſcovered the motion of the heart but very inaccurately in the Ephemerus, and only in that part of it which I here repreſent in the figure; but I have entirely forgot, againſt which of the annular ſections it was placed in the back.

The ſpinal marrow, Tab. XIV. fig. I. *y y y*, is wonderful and very worthy of notice in this, as it is in all other inſects that I have diſſected; it conſiſts as of eleven knotty tubercles, ſomewhat long and oval. The firſt of theſe knotty little parts ſerves inſtead of a brain, out of which * * the optic nerves may be very diſtinctly ſeen to ariſe and ſpread themſelves. In the ſame manner I have obſerved, that the reſt of the nerves iſſue from the ten ſubſequent little knots; but theſe that ariſe from the lower knots, are not ſo numerous as thoſe from the upper. The ſpinal marrow is moreover found to be here and there beautifully ſtrengthened with ligaments *z z*, which are compoſed partly of a ſtrong horny ſubſtance, and partly of tendinous wreaths or faſciæ. This is the caſe in the breaſt in particular, for there the ſpinal marrow ſends out a great many nerves to the muſcles, *α α*, *β β*, which move the legs and wings: the ſame thing happens about the muſcles of the branchiæ, Tab. XIV. fig. 1. *c c*, and rowing fins.

From each little knot, Tab. XIV. fig. 1. *e e*, of the ſpinal marrow, there conſtantly iſſue two ſtronger nerves, which unite and become more ſwollen when they approach the ſubſequent nerve; for which reaſon the ſpinal marrow appears every where divided and open. But while it is in its ſtate of nature contained within the body, that gaping does not appear; becauſe the nerves are there only ſimply contiguous to each other, and do not therefore appear to be far diſtant from each other; as I have ſhewn in the ſixth figure, Tab. XV. in which the ſpinal marrow, as it is naturally contained in the body, and the fourteen annular inciſions of the creature wherein the marrow lies are delineated.

If any one has a mind to view the ſpinal marrow, without hurting or injuring the creature, let him fill the body with air blown in through the hinder part: for thus the marrow will be by the force of the ſwollen inteſtines ſo ſtrongly preſſed againſt the tranſparent skin, that one may conveniently view its natural ſituation and form, even with the naked eye, as well as with a microſcope. But this contrivance can be uſed in the males only.

The ſpinal marrow, as well as the other parts of the creature, has its air-pipes, and indeed a great number of them; ſo that the brain and nerves are continually as it were ventilated with injected air. I do not doubt but the marrow has veins and arteries, though I never ſaw them; for in Silk-worms I have clearly ſeen various ſmall veſſels ſpring from, and approaching to the heart, which I have even filled with a coloured liquid. But whether they were veins or arteries, I cannot yet affirm.

The ſpermatic veſſels, Tab. XIV. fig. 1. or genital organs, are as conſpicuous in the male of theſe Worms, the day before it changes its skin, as in the male Ephemerus, or the Fly thence produced after changing its coat. Theſe ſpermatic veſſels are found to be placed on each ſide of the ſtomach and inteſtines, and appear like the ſmall guts in Fiſh. There are, however, ſome bendings and windings in them, like the ſeminal veſicles in the human ſpecies and they are found in manner of tubes: therefore, in this reſpect, they are alſo analogous to the ſpermatic veſſels of ſome quadrupedes, as Moles, Hedge-hogs, and the like. They are in theſe, Worms of an oblong figure *fffff*, and are extended all over the belly, as is evident from the annexed figure, wherein I exhibit one of them taken out of the body, and the other ſomewhat larger than nature in it. They contain in their cavities a very white humour like milk, which is the ſperm. The ſeminal veſſels themſelves are likewiſe perfectly white, and they are of a thin and membranous texture, and have many air-tubes all over them both within and without.

In the lower rings of the abdomen appear two other little parts *d d*, which likewiſe in my opinion belong to the ſpermatic veſſels; for they ſeem to have a common paſſage with them and with the inteſtines, Tab. XIV. fig. 1. *δ*; which however I could not at that time ſo accurately diſcover, being engaged in other parts of this diſſection. And indeed we muſt diſſect a great number of theſe inſects, if we would endeavour to diſcover the whole fabrick, ſearching in another what we could not examine to our wiſhes in the former; and even with this caution we cannot always execute our deſign perfectly.

The ovary is double in the females, Tab. XV. fig. III. and it is placed in the ſame manner as the ovary in Fiſhes. But if the skin of the abdomen be opened a little way with a fine and ſharp-pointed pair of ſciſſors, that congeries or heap of eggs, fig. 1. *ll*, ſituated on each ſide of the ſoft part of the belly, comes in ſight. Between theſe, in the middle, the ſtomach and inteſtines *ff* are ſomewhat obſcurely ſeen through the other parts, and the latter are themſelves ſtrongly connected with the membranes *m m* of the ovary. The ſtomach and little inteſtines appear the more plainly, the more they are filled with mud, which is the food of the Ephemerus; and for this very reaſon the eggs may be ſeen alſo more beautifully; for their whiteneſs, ſhewing itſelf brighter on account of the diverſity of colours, makes them the more diſcernable.

The double ovary of the Ephemerus has innumerable air-pipes, which are tied to a ſmall membrane that ſurrounds the ovary; and by means of the latter they are conveyed to the little eggs hidden on the inſide. But if this membrane be removed with the point of a fine needle, and ſome part thereof put together with the eggs into a ſpoonful of water, the eggs immediately ſeparate from each other, and there remains a fine, delicate and tender bundle of minute veſſels, fig. VII. *g*, which I take to be moſtly air-pipes, being like fine filaments, and conſpicuous by their colour like mother of pearl.

The eggs are likewiſe ſo extremely ſmall, fig. II, that they can ſcarce be ſeen. It is therefore neceſſary to view them with a good microſcope, and to put them on black or blue paper, which contributes to their being the better diſtinguiſhed.

The eggs are of a plain round and oblong figure, and are ſurrounded with a tolerable firm membrane, which appears cloudy under the microſcope, and they are of a white colour, like the inner skin of an egg-ſhell. Since therefore the eggs of the Ephemerus are ſo ſmall and delicate, the reaſon is evident, why the Worms iſſuing from them muſt be increaſing three years before they come to perfection, and are able to commence their change.

CHAP.

CHAP. VII.

The ſigns by which to diſcover, whether the Ephemerus is to fly in a ſhort time; as alſo what may prevent it, and to what claſs or order of natural changes it belongs.

THE general preceding ſigns of the approaching change of the Worms of the Ephemeri into flies, are, in regard to the weather, a warm and dry ſpring; a mild winter, without much rain or ſnow; and a gently running water. The peculiar ſigns whereby to know that theſe Worms will change into Flies in a ſhort time, conſiſts in a protuberance of the wings on the back; for about that time the ſmooth and depreſſed form of the upper part of the body is changed into a more ſwollen and rounder ſhape; that is, that glutinous fluid which is at other times found in the coats that ſurround and defend the wings, becomes thicker and more clammy: hence it is, that the wings are at that time in ſome degree viſible through their external skin, Tab. XIII. fig. VII. *aa*.

Theſe ſigns are more certain when the colour of the wings within is obſerved to change from a yellowiſh and paliſh to a grayiſh hue. There is alſo a ſtill greater certainty, if, after the external coat of the wings is taken off from the inſect's body, the wings can be expanded without hurting them: as appears in Tab. XIV. fig. I. under the letters εεε; where I exhibit the magnified wing, and as it is artfully folded by nature.

Another ſign likewiſe preſents itſelf in the diſſection of theſe inſects: that is, when we find the genital parts and eggs have acquired their full bigneſs, their due hardneſs, and true figure. We may then take the whole creature out of its skin, by art, and by this contrivance change it into the form of a flying Ephemerus ourſelves, not waiting the moment of nature.

All the viſcera of this inſect are then cleared from their contents, which were a kind of dirt; nor is there any thing in the ſtomach and inteſtines but tranſparent and depurated humours, which appear the more dusky, foul, and coloured, the further the time of the change is diſtant; ſo that they are ſometimes yellowiſh, and ſometimes dusky and red. At other times a little mud is found in the extremity of the thick and ſtraight gut and colon; but, on the contrary, theſe inſects are all over clear and tranſparent, when the time of their change is juſt at hand.

The following accidents keep back the changes of the Ephemerus, deſtroy its life, or prevent its growth; inſomuch that ſo great numbers of theſe inſects are not produced as might be expected; nor do they come to ſuch maturity. An inclement, boiſterous, tempeſtuous, long, rainy and ſnowy winter, deſtroys numbers. By this the cells inhabited by the Worms are deſtroyed, being worn out, or ſhut up and covered with ſand. Too much drought or dry weather afterwards occaſions the ſame deſtruction; for they are then compelled to quit their little cells, and make themſelves new ones from the decreaſe of the water; and many are loſt in this operation. From what has been ſaid, we may eaſily ſee what favours and what injures the Ephemerus; what leſſens it troubles and misfortunes, and what increaſes and multiplies them.

What I have a little before advanced concerning the maturity of the wings, ſhews to which of the orders of the four natural tranſmutations this inſect belongs; that is, to the ſecond claſs or order. For all the inſects of this order are changed in the ſame manner as the Ephemerus.

Indeed, Clutius feigns that the Worm of the Ephemerus is changed into a Nymph of the third order, and on this loſes all its motion, like the Nymphs of Silk-worms; he even exhibits a figure of that Nymph, though there is no ſuch thing in all nature. Hence it is evident how much they are deceived who neglect the truth of experiments, and give credit to their own reaſonings, or to the falſe relations of others.

CHAP. VIII.

How and in what a wonderful manner the Worm is transformed into an Ephemerus.

WHEN the time of the change of the Worm of the Ephemerus is approaching, and the wings, Tab XIII. fig. VII. *aa*, hidden in the caſes or huſks, have acquired their due ſtrength and form, and that it is no longer in the power of the Worm to delay its change; thoſe which have their parts thus diſpoſed and prepared, march out of their habitations into the water. This uſually happens in the evening between ſix of the clock and half an hour after. This I obſerved on the thirteenth of the month of June, in the year 1671, purſuing the change of the Worms of the Ephemerus.

The other Worms, which are not as yet come to this ſtate of growth, remain in their cells. Thoſe which have crept into the water move forward, and make all the haſte they can from the bottom to the ſurface; which, when ſome more ſwiftly and others more ſlowly are arrived at, each of them, fig. VII. is changed into a winged inſect, fig. VI. and VIII. But this change or caſting of the ſkin is ſo ſuddenly performed, that even the moſt attentive perſon cannot otherwiſe judge, than that the Worm breaks or burſts its way and ſwiftly flies out of the middle of the water.

Every inſect that I have hitherto obſerved has a certain and determined time appointed for it by the omnipotent God, to expand its wings and dry them, that they may become ſmooth and poliſhed, before they are able to prepare themſelves for flight. But the Ephemerus, on the contrary, is almoſt at one and the ſame point of time a reptile and a flying creature. Wherever one ſees at this time a little water bubble up, if we caſts our eyes on the ſurface, there is immediately a winged inſect obſerved to iſſue out of the middle of the water. Argus would want eyes, if he ſhould attempt to trace theſe miracles of the adorable Creator of the univerſe.

If any one goes into a boat and fixes in a ſituation directly againſt the deſcending ſtream of a river, then he may very well ſee theſe inſects emerging or riſing up, and caſting their ſkin. For, though you ſhould as ſoon as poſſible catch the Worm ſtill floating on the water, yet you can ſcarce look at it before it is winged and flying. This may however be prevented, and the Worm taken out of the river before the change is performed, if it be ſtruck a little, or bruiſed on the breaſt; which is neceſſary to be done, if one would view the creature at this period not yet changed, but covered with its ſkin.

It is difficult to ſay what is the reaſon that theſe wings are ſo ſwiftly expanded, and yet have neither muſcles nor joints in them, but only artificially plaited and folded; nay, they muſt again change their ſkin the moment after. This difficulty ſurely is very worthy to be ſolved. I indeed thought it neceſſary that theſe wings ſhould be provided with muſcles and joints in the ſubſtance of them, as we have obſerved in many other inſects; for the latter can by the help of ſuch joints and muſcles very artificially contract their wings into a narrow compaſs, and again quickly unfold or diſplay them. This holds, amongſt the reſt, in Ear-wigs, which hide or put up very long wings in a ſmall ſheath, which folds and covers them ſo neatly, that they ſeem to be quite deſtitute of wings. But though the Ear-wigs can by the power of muſcles and joints, which they have in the middle of their wings, cloſely fold theſe wings in the ſame manner as in the Ephemerus, which has not yet gone through its change, and again quickly expand them; and though I thought the Ephemerus was in need of the like aſſiſtance, yet the ſupreme Architect has not been pleaſed to make uſe of the ſame ſtructure; and it appears that even this ſtructure was not neceſſary.

If the trials that I have hitherto made can throw any light on this inſtantaneous expanſion of the wings, it muſt conſiſt in this; that I think the water, which is warmer on the ſurface than in the bottom of the river, flowing all over and penetrating into the wings, contributes very much to their expanſion. For by the aſſiſtance of the water, the blood which is then driven out of the heart into the wings, in order to promote this needful expanſion, may be impelled with greater force, in the ſame manner as we ſee the blood is, by the help of hot water, drawn more plentifully into the feet, and thoſe parts are more diſtended when any one is blooded in the foot. Thus, becauſe the blood and all the humours in this inſect, when it gets into the water ſwims about and is employed in changing its skin, are violently moved; hence the ſurrounding water may be of great ſervice to impel the humours contained in the wings, ſo that they may be more expanded. Wherefore we likewiſe obſerve that in the wings of inſects, if wounded at that time, there follows a mortal hemorrhage, or if the creature ſurvives, the wings are never afterwards diſplayed. To the more ready expanſion of theſe wings, the impelled air likewiſe probably contributes very much, becauſe it is conveyed thither through the numerous pulmonary tubes, and may ſerve for giving ſtrength and firmneſs to the pulmonary pipes, and for expelling the humour from thence. If you cut off the wings of the Worm of the Ephemerus when it is very near its change, and throw them into a baſon of water, you will immediately ſee them expanding by force of the water flowing round them, and at length extending themſelves into their natural, ſmooth, and even ſurface, ſo that they would ſerve the creature to fly, if they were dry and ſtrong enough. I have often made this experiment on the wings of this inſect, and by that means have in ſome meaſure learned how they are expanded. When I have put them in the water, in the manner beforementioned, I have obſerved that their larger folds were firſt opened, Tab. XIV. fig. I. ε ε ε, and then, by degrees, the wings were ſtretched out in length, Tab. XIII. fig. IX. Afterwards the longitudinal plaits of the wings were expanded, fig. X. until at length the whole wings, fig. XI. were entirely ſhewn open. This may be ſeen in the inſect itſelf, fig. VIII. which I have delineated from the life; but the figures of the wings beforementioned are drawn with the help of a microſcope. So long as the wings continue in their plaits and folds, they are of a dark gray colour; but this by degrees becomes more faint when they are expanded.

When the Ephemerus has, fig. VI. and VIII. taken its firſt flight, it ſeeks out with all ſpeed for ſome place where it may quietly reſt; and having found ſuch a one, it caſts off, fig. XII. and XIII. a very thin and tender skin from its whole body, that is, from its head, breaſt, belly and wings. But before I treat of this other change of the skin, I muſt obſerve that it is always made on dry land, whereas the former is conſtantly performed in the water. And the firſt change is likewiſe much more admirable and worthy of obſervation than the ſecond. When the Ephemerus firſt caſt its skin or outward coat on the ſurface of the water, it at that time entirely loſes its former ſhape; but this is not the caſe in the ſecond change.

Therefore under the firſt of theſe changes, in which the skin of the Worm opening on the head and back, ſuddenly is ſeparated from the body, until the Fly ſpeedily and quickly makes its way from thence, ſome very conſiderable parts are loſt, that is, fig. IV. *ff*, all the branchiæ or gills on each ſide, together with the ten rowing fins under them. Nay, when theſe branchiæ are ſeparated, they do not leave even their hairs upon the body, but all vaniſh away ſo entirely, that only ſome ſmall veſtiges or points remain of them, which form a little margin or border on the ſides of the belly. The Ephemerus loſes alſo its teeth or forceps *c*, and the former ſhape *d d* of its legs, and the caſes of its wings *e*, and tails *g*, and other parts. Hence the Ephemerus having gone through this change of its skin, is become as it were another creature. fig. VI. and VIII.

But as it is very difficult, perhaps impoſſible to obſerve all theſe things in the very ſhort ſpace of time in which the skin is caſting, any perſon may do this at his leiſure, if he gently and dextrouſly ſtrips the Worm, that is to change immediately, of its skin. For then the parting branchiæ or gills, which adhere to the exuviæ or caſt skin of the Worm, are ſeen very plainly: there likewiſe appear thoſe prominent apiculi or points they leave on the body of the Ephemerus itſelf; nay, you may likewiſe ſee thoſe little holes which received the apiculi or points juſt mentioned. The pulmonary tubes may be likewiſe ſeen. Why ſhould I ſay any thing of the muſcles, tendons, veſſels, and nerves which are ſeparated from their membranes, like ripe fruit falling from a tree? for neither reaſon, obſervation, nor experience can diſcover any thing of them, ſince they are all directed by the omnipotent wiſdom and providence, and conducted in ſuch a wonderful manner that they are altogether incomprehenſible.

Again, though many parts of the Worm of the Ephemerus are extended and become longer under the firſt change of its skin, yet the horns which project from the fore part of the Worm's head only caſt their skin, and when it is off they become more ſlender and ſhort in the flying Ephemerus than they were in the Worm itſelf. The change that happens about the eyes merits yet greater attention, for their cornea tunica which was of a ſmooth and equal ſurface in the Worm, ſeems in the Ephemerus, after caſting its skin, to conſiſt of a congeries of many eyes, which form a little net equally divided. The legs likewiſe, together with two of the tails, become as long again by the change: but the third or middle tail is entirely taken off, having ſerved no purpoſe but to the Worm.

When I ſay the two eyes of this creature are compoſed of a congeries of leſſer eyes, ſix, nay ſeven thouſand of which I have obſerved thus cluſtered together in ſome inſects, whereas in others, as Spiders and Scorpions, they are diſperſed all over the body; I would not have any one conclude from thence, that theſe eyes are formed as they are in the human ſpecies and other known animals. They are by no means ſuch, for they want the humours; but every globular diviſion of them emits an hexagonal filament like a needle, which terminates in the net-like tunic or coat of the eyes, and this coat itſelf ends at the nerve and brain: ſo that theſe creatures ſee in a different manner from us. We ſee by the aſſiſtance of rays collected on the inſide of our eyes, but theſe perform viſion by a collection of nervous filaments, which, when they ſee, are lightly and gently affected and moved in their prominent extremities by viſible objects, and by the rays of light or colours and other appearances, as I have deſcribed at large, and expreſſed in figures in my treatiſe on Bees.

As to the ſucceeding change of the skin of the Ephemerus, which immediately and without interruption follows the firſt, we are to obſerve therein, that the Ephemerus having once caſt its skin, chooſes no particular place to reſt or ſettle in, in order to undergo the other.

It fixes upon any place it can find in its flight, and it does not regard whether it be wood, ſtone, earth, a tree, a boat, a ſhip, a beaſt, or a man. It ſeems to be a moſt innocent little creature indifferent to every thing, ſo that it can reſt any where, in order to caſt off this ſecond skin, which is done in the manner following.

The Fly firmly and ſtrongly faſtens its legs, which are armed with ſharp claws for that purpoſe; then it appears as if ſeized with a ſhuddering and trembling motion, and immediately its skin opens on the middle of its back in the ſmall ſhield that is placed there: this opening becomes by degrees ſo large towards the fore parts, that the creature can thruſt its head out of it. After this it draws its legs alſo out of the skin, Tab. XIII. fig. XII, XIII. whilſt the claws, adhering to the caſt skin, are in the mean time ſtill firmly fixed in their places; and this indeed contributes much to remove the skin from the reſt of the body.

Moreover, it muſt be well obſerved, that the head and legs are ſtript of their ſkin in the ſame manner as we draw our feet out of our ſhoes, or our head out of a narrow cap. But as to the other parts, namely, the firſt and ſecond pair of wings, the ſkin is drawn off from them in ſuch a manner, as that the inſide is turned out and the outſide in, as we invert a limber pair of gloves, the inward ſurface or inſide of the fingers being pulled out. At the time when half the ſkin is drawn off the wings, theſe inſects are as helpleſs captives, and fixed in that condition, fig. XII. they even lie for ſome time without any ſenſible or remarkable motion. The reſt of the body is likewiſe by this ſecond change extended and becomes much longer, and the tails become a third part longer than they were after the firſt change. So that the tail and legs which were made, under the firſt change, a third part longer, are now again as much more lengthened; but this holds more perfectly in the tails than the legs. For, as the tail conſiſts of hollow rings which are capable of being drawn out from each other, hence its extenſion is much more conſpicuous than that of the legs, becauſe the latter only lay folded in the ſkin, but are now extended fully to their length, and nothing more. It is moreover to be obſerved in regard to the tail, that its hairs, which were planted very thick in the Worm of the Ephemerus, are placed more remote from one another when it flies, and they alſo become much finer and thiner, ſince they likewiſe caſt their ſkin twice, and appear iſſuing out of their hairs as out of little ſheaths.

The Ephemerus having thus partly ſhaken and partly drawn off its ſkin, by inverting or turning it inſide out, being now perfect, ſeeks again the water, on the ſurface of which it flies and beats up and down gently and quickly, and, as it ſeems, wantonly ſports and plays, and then reſts again, leaning on its tails, and ſtriking its wings againſt each other. Whilſt the Fly is thus in motion on the ſurface of the water, and looſely playing with its wings, its tail, which is hollow and full of hairs, very eaſily ſupports the body; for, as it contains air in it, it is therefore carried lightly upon the ſurface of the water, and does not ſink under it. Something like this is obſerved in ſeveral other inſects, which will continue in the ſame manner, ſuſpended on the ſurface of the water by the help of hairs, within and between which the air is detained, as is the caſe in the Worms out of which Gnats and Gad-Flies are produced. The air, however, does not always continue in the tails of the Ephemerus, but ſometimes comes out of it, and may at any time be let out if they are pricked with a needle, in order to dry and preſerve them; for then they generally become corrugated or wrinkled, and ſink or fall together. There is alſo another reaſon why the Ephemerus flies thus lightly on the ſurface of the water, and that is, becauſe it carries a ſmall bladder full of air in its body; unleſs we ſhould rather incline to think that it is the ſtomach of the Ephemerus, which is then inflated or blown up with air. But I ſhall affirm nothing certain concerning this matter, ſince it is not ſufficiently clear to myſelf.

The male, fig. VI. as appears to me, changes its ſkin twice, but the female, fig. VIII. only once. I do not, however, advance this as undoubted truth, ſince I have not yet confirmed it by a ſufficient number of experiments. For this reaſon, if it be thus, we obſerve that the tails of the female are a third part ſhorter than the tails of the male. Beſides, another more remarkable difference is, that the eyes in the male are twice as large as in the female. A third difference is, that the yellow colour of the body in the male approaches more to red than in the female. The male likewiſe has, beſides his two larger tails, four appendages, like crooked little tongues, which cannot be ſo diſtinctly ſeen in the female. Theſe are the great differences of the two ſexes.

The Ephemerus does not engender either in the body of the water, or on land, nor in the air, but the female throws out her eggs on the ſurface of the water, and the male afterwards caſteth his ſperm upon them *, and he has probably, for this purpoſe larger eyes given him by the all-ſeeing Creator, that by means of this advantage he may eaſily find out the eggs of the female wherever ſhe has dropped them. As therefore a great many ſpecies of fiſh without coition throw out their eggs into the bottom of the water, to be afterwards impregnated by the male, ſo the Ephemerus throws its ſperm into the water. Theſe eggs, when caſt out, are not collected and concreted together in the form of a perfect ovary, like that which the Ephemerus carries in its body, but are ſeparated and diſperſed from each other as they are in fiſh. That the Ephemerus while a Worm does not perform the buſineſs of coition in the water, is manifeſt from hence, that it does not come out of its cells only at the time it is to caſt its ſkin. Nay, if it ſhould go out of them, as it ſometimes does through neceſſity, or to breathe freſh air, yet it is by no means able to do any act to propagate its ſpecies in the water, for it cannot remain ſuſpended in the water but while ſwimming, and it ſinks immediately to the bottom when it has a mind to reſt in it: but at the bottom it has no fixed reſidence till it has made a new cell or habitation for itſelf. To theſe we may add another, the ſtrongeſt argument of all, that is, that no inſect ever enter upon the buſineſs of

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* This, though common with fiſh, is ſtrange among the inſect kind; but in the whole compaſs of natural hiſtory nothing is more variouſly performed than the impregnation of the eggs, nor any thing ſo little underſtood; it ſeems, they may not only be impregnated by a male ſperm caſt upon them when laid by the female, but even by the ſame fluid caſt at random while they are yet in the body of the female. Monſieur Demours is particular in his obſervation of the water Newt, the male of which has no penis, but diſcharges his ſperm in the water near the female, whoſe eggs, though none of the ſperm abſolutely enters her body, are ſo impregnated.

generation, until they have caſt their laſt skin. At leaſt, I have been taught ſo by all the experience I have had in their examination.

Neither do the Ephemeri breed or engender in the air; this may be eaſily obſerved when they fly. Beſides, they could not poſſibly breed in the air, becauſe the legs of the males are ſo vaſtly lengthened after the laſt change of the skin, that Clutius took them for horns. Thoſe who would favour ſuch an opinion, muſt conſider what an apparatus is neceſſary for ſuch coition in the air; as may be ſeen in thoſe Flies which do it, and particularly in the Libellæ, which perform their venereal embraces in a wonderful manner, flying and wandering all the time in the air, viſibly coupled a long while together.

I therefore conclude from all my obſervations, that the Ephemeri never engender together, either in the air or water, but that the female only throws her eggs on the water, and the male afterwards pours its ſperm, which it carries about it flying, as the female does its eggs, upon them; ſo that this operation is performed without any communication of the two ſexes. All theſe things are haſtily tranſacted in the ſhort period of a moſt tranſitory life, ſo that a more accurate inquiry into them cannot poſſibly be made.

Theſe little creatures do not eat in the whole courſe of their lives, while perfect flying creatures, as is alſo the caſe with many other inſects. I have likewiſe found by experience, that Frogs, Lizards, Serpents and Cameleons, are capable of living without eating many weeks; nay months.

CHAP. IX.

How long the Ephemerus lives, and what haſtens its death.

THE Ephemerus thus flying about and wandering over the ſurface of the water, and moving ſometimes up and ſometimes down through the air, never lives more than four or at moſt five hours, that is from ſix of the clock in the evening, or half an hour after, until eleven at night. This I ſay from experience, becauſe I have carried ſome of them encloſed in a box into my chamber, and there accurately obſerved the length of their lives. All die in this very ſhort ſpace of time, nor do any of them, which is a matter very worthy of obſervation, die a natural death on land. All of them invariably go to the water again, after they have gone through the ſecond change of their skin. God therefore, the ſupreme artiſt, has been pleaſed to aſſign this inſect a ſhort life that ſurpaſſes all adoration.

Who has ſo great a genius, or is ſo converſant in the art of writing, as to be able to deſcribe, with a due ſenſe, the trouble, and misfortunes this creature is ſubject to, during the ſhort continuance of its flying life. For my part, I confeſs I am by no means able to execute this task. Nor do I know whether nature ever produced a more innocent and ſimple little creature, which is, notwithſtanding, deſtined to undergo ſo many miſeries and horrible dangers.

Beſides, that the life of the Ephemerus is ſhort, nay, amazingly and incomprehenſibly ſo, an infinite number of them are always deſtroyed in the birth, being devoured by fiſh. Nor does Clutius acquit any ſpecies of fiſh of this barbarity except the Perch and Pike. Though the reſt of the Ephemeri have eſcaped this cruel danger, yet on land, when they are engaged in the great work of changing their skin, they are barbarouſly devoured by Swallows and other birds. Nay, if they eſcape this danger, when they afterwards approach again to the ſurface of the water, and careleſsly ſport and play there with their wings and tails, they a ſecond time become a prey to the fiſh, which drag them away to the dark bottom of the water and devour them. If they fly higher into the air, another kind of torment attends them, for then they are perſecuted with a different barbarity by other kinds of birds, which tear their limbs aſunder and devour them. Though theſe inſects then are the moſt innocent, perhaps, of all others, they are more cruelly treated or uſed than the moſt miſchievous of wild beaſts.

As the Ephemerus abounds with uſeful leſſons and moral precepts, ſo it affords ſufficient matter for various ſpeculations. It is ingendered, grows to its bigneſs, and then generates, lays eggs, caſts its ſperm, grows old, and dies in the ſpace of five hours. This ſhort time comprehends the morning, noon and evening of its life.

When the Ephemerus is flying, and particularly a little before the end of that time, the Trout, which eats it as its food, comes to its perfection: its fleſh and flavour being finer than at any other time. This I have been aſſured of by Nicholas Tulpius, formerly conſul at Amſterdam, for he fairly made trial of the matter.

One may ask further this queſtion, why, excluſive of all thoſe dangers and misfortunes, the life of the Ephemerus ſhould be ſo ſhort? In anſwer to this let it be obſerved, that the eggs of the Ephemerus, whilſt it ſtill ſwims as a Worm, are arrived to their perfection, ſo that as ſoon as the inſect is increaſed and perfected by changing and extending its limbs, thoſe eggs are inſtantly fit for production or birth: to which may be added, that the Ephemerus has not the nouriſhing of its offspring; wherefore God has made this creature likewiſe, more than others, void of reaſon, as the Oſtrich among birds, that He, from whom ſprings all reaſon and knowledge, might take upon himſelf the care of nouriſhing its progeny.

Since therefore this creature aſſumes its winged form only to propagate its ſpecies, it follows, that when this is done, its death is naturally near at hand, and for this purpoſe it ſeems to remain three years hidden in the water and mud, and to undergo after that time its change, and get wings in that form living, till this buſineſs of generation is performed, and then it dies.

CHAP. X.

That the Ephemerus kind flies three days and ſometimes four: certain other ſpecies thereof are alſo deſcribed.

THAT the Ephemeri are changing and flying during three days continually, is known to all who live near the rivers, famous for this annual miracle; I have obſerved them flying the fourth; nay, even the fifth day, but then very few in number. Theſe were a ſucceſſion of the inſects hatched one after another, and hence I think theſe had been Worms of the ſame year, the wings whereof had acquired their maturity ſomewhat ſlower than ſome others; and that theſe latter were ſick, or prevented by ſome other impediment, which hindered their change in the appointed time. As, on the other hand, it is certain that the transformation of the Worms of this ſpecies, which are changed before their time, happens on account of their wings and other parts being perfected earlier than natural. As this may and certainly does happen in all the inſect kinds, I ſee no reaſon why the Ephemerus ſhould not ſometimes be produced in its winged form, ſome days ſooner or later than the ſtrict time, ſince it is certain from experience that the general change of them may happen fourteen days ſooner or later, as the ſeaſon of the year favours it more or leſs.

If we attentively conſider the things that have been here related of the Ephemerus, it is evident that Mouffet ſpeaks truth, when he ſays, "The Ephemeron, or Diaria is a wonderful "Fly, whether we conſider its make or the "ſhortneſs of its life." But ſome of the other particulars related of this inſect by this author, as well as by Aldrovandus, Johnſon, Clutius, and others, who are cited by all the latter writers, do not much correſpond with the truth. Far be it from me to reprehend or animadvert on others in theſe matters; ſince it is poſſible that theſe gentlemen might have deſcribed a different Ephemerus from mine, as there are various ſpecies. Beſides, nature, or her author God, is perfectly inexhauſtible in the make, properties and diſpoſition of theſe creatures. I ſhall only recommend it to any who ſhall be deſirous of knowing the truth, to conſult the inſects themſelves; for nature far ſurpaſſes all the writings and treaties that can be compiled, and in this and all other caſes will teach more in one inſtant of time than any one can learn in a long ſeries of years out of the beſt library.

It aſtoniſhed me to ſee in a book written by Augerius Clutius, that Dortmannus there exhibited a figure of the Ephemerus, deviſed upon a weak and erring memory, or feigned from mere imagination. Goedaert having obſerved this, and being furniſhed with many more obſervations of that kind, undertook to amend it of his own pleaſure, but without ſucceſs; ſince he changed nothing but what appeared to his fancy to be improper, and left the whole figure of the inſect, which was delineated from memory only, altogether incorrect. As he attempted to correct theſe errors from his own imagination, it ſhould ſeem to follow that he multiplied them, although he rendered them more ſeemingly like the truth. Indeed Goedaert himſelf owns he never ſaw this inſect.

While I was engaged in inveſtigating the nature of this inſect, I met with various ſpecies of it at different times, but I never had the good fortune to ſee the Ephemerus of Hoefnagel, which Clutius delineates; and which is found alſo among the figures of Hoefnagel. But I once found its Nymph troden upon in the road that goes by the lake of Deimermeer. I at that time thought it had its origin from a kind of blackiſh and toothed water Worm, which has a cloſely corrugated or wrinkled skin; ſince the latter having attained its full bigneſs, leaves the water, and betaking itſelf to land, is there changed into a Nymph, which in proceſs of time, perhaps, acquires the form of the Ephemerus delineated by Hoefnagel. This Ephemerus afterwards throws its eggs into the water, which is the caſe with many other inſects, and with ſeveral other ſpecies of the Ephemerus which I can ſhew. I ſaw and took ſome of thoſe ſpecies in the river Loire at Saumeur in France. Theſe do not differ in their general form from the Ephemerus of our country, but they are leſs, and of a ſomewhat different ſtructure. I have ſeen great ſwarms of theſe flying, when I chanced to walk in the evening on the bridge that is over the river at Saumeur. Some of theſe carried about them their ſecond skin ſtill ſticking to their tails, as they flew up and down above the bridge. I have nothing farther to ſay of this kind, or of all other ſpecies which I preſerve, only that ſome of them are as ſhort lived as our Ephemerus, which I have been hitherto deſcribing,

deſcribing; but I have obſerved that others of them live longer than theſe. I therefore apprehend that the various ſpecies are diſtinguiſhable from each other by ſeveral further peculiarities; and, for this reaſon, I do not pronounce thoſe authors reproachable, who relate any thing of theſe or of the like inſects, becauſe what they ſay does not exactly agree with the ſpecies of one particular country. Far be it from me to be guilty of ſuch temerity; ſince God is infinite in all his works, and the ſpecies may be numerous.

About the end of June 1670, when I reſided in the village of Slooten near Amſterdam, I went ſometimes in the evenings into the fields, where ſo great a number of minute inſects which were ſomewhat larger than Gnats, at times pitched on my cloaths, that I was all over covered with them. Each of theſe caſt a ſmall ſkin on my cloaths; after which, I obſerved that all of them returned to the water, and there, like the larger Ephemerus, ſported and beat up and down. Theſe inſects are produced nearly in the ſame manner as the Ephemerus before deſcribed; for they live in ditches and water-trenches, and when they are to ſuffer a change into the Fly ſtate, they likewiſe, at regular times, caſt two skins, one in the water and another on the land. The Worms of the ſmaller Ephemerus differ from the larger, in that they do not hide themſelves in mud, or form cells or long holes, but moſtly inhabit ſtony and ſandy bottoms: therefore nature has formed them of a rougher and more robuſt conſtitution than the larger Ephemerus. Their skin alſo is more like the cruſtaceous integument of Crabs and Shrimps. They have likewiſe branchiæ or gills, and rowing fins on the ſides of their bodies. When in the middle of ſummer any one takes up ſtones from the Rhine or Leck, or other collections of waters in our own country, for carrying to the land, he will moſt commonly ſee ſome Worms of that kind ſticking to them; which is likewiſe the caſe in other countries and other rivers, as I myſelf have learned from experience in the Loire, the Seine, and other rivers of France. Hence it is evident that there are many diſtinct ſpecies of the Ephemerus, and that the authors who deſcribe an Ephemerus, however different from that of our country, do not merit certain cenſure. I can for the moſt part exhibit to the naked eye the Worms before mentioned, and every thing that I have hitherto advanced concerning the Ephemerus, according as they are in nature; ſince I have preſerved them to this day, that they may ſerve the better to illuſtrate and confirm what is ſaid in this treatiſe.

The end of the wonderful hiſtory of the EPHEMERUS.

The THIRD ORDER.

Of natural changes, or ſlow accretions of the parts of inſects.

HAVING explained in the preceding chapters the two firſt orders or claſſes of natural changes, we now advance to the third; which, we muſt obſerve, is always preceded by another change, as we have before deſcribed at large.

As this change is more obſcure and intricate than the firſt, and more difficult to be underſtood than the ſecond, in order to give a diſtinct and plain deſcription thereof, we ſhall compare it with the firſt and ſecond; for by this means it will be eaſier to comprehend what they all three have in common, and in what they differ from each other. As the firſt order of tranſmutations conſiſt in this, that the creature increaſes in its parent from almoſt inviſible, but really exiſting rudiments, and lies encloſed in a membrane until it has acquired ſufficient ſtrength therein to be able to creep out of it; ſo on the other hand, the other order is much more imperfect; for in this the inſect increaſes likewiſe as in the firſt order, but it comes out of its egg imperfect; and therefore becauſe in ſome parts, but chiefly in regard to the wings, it is ſtill defective; it muſt, in order to acquire its due perfection, take in food from abroad; by the help of which, the reſt of its parts, which we from time to time obſerve to increaſe and expand, like a flower from its cup, are at length perfected.

The order of nature is quite contrary in thoſe inſects which undergo the change of our third order: for though they increaſe in the ſame manner as thoſe in the firſt order, and come forth imperfect, as thoſe in the ſecond order, nay, much more ſo, out of their egg, many of them not having even legs; yet all theſe imperfect parts are increaſed and augmented in a very obſcure manner under the skin. Hence, as the creature iſſues complete in all its parts out of the egg in the firſt order, and in the ſecond the accretion or expanding of its ſeveral parts is performed externally and openly; but in this our third order, on the contrary, this germination or ſprouting is all tranſacted within the covering of a skin, and can with very great difficulty be obſerved, unleſs by the change of the skin.

As therefore thoſe inſects which undergo the firſt order of tranſmutation, conſtituted under the form of a Nymph, creep only ſimply out of their egg or ſkin: and as thoſe which belong to the ſecond order of changes, likewiſe expand afterwards as it were into a ſecond Nymph; though in the mean time they do not ceaſe to move and eat, nor do they ever at any period of their lives loſe their motion; ſo on the contrary the matter is quite otherwiſe in thoſe which are ſubject to our third order of tranſmutation; for as ſoon as theſe which firſt iſſued imperfect out of their egg or former Nymph, and increaſed in their parts as they have grown under the ſkin, like a flower in a tender flower cup, and afterwards caſt this ſkin by the force of the protuberant parts; under this other transformation they entirely loſe all their motion, except that of the tail only; for this is not ſwollen with moiſture in a great many, and only changes its ſkin.

The inſects which undergo this third order of change, are produced imperfect out of their egg, and want at that time a great many of their parts: but they by degrees acquire them under the cover of their ſkin, where they are gradually perfected and enlarged. The legs, wing, horns, and the reſt of their parts are by this means increaſed to their due ſize with the body: this is performed inſenſibly by abſolute growth or addition of parts. Finally when the limbs are come to the full period of their increaſe, they raiſe the ſkin with a viſible ſwelling and render it ſomewhat prominent in different parts; and under theſe protuberances of the ſkin, we can plainly diſcern the ſeveral limbs and other parts which lie diſpoſed in a wonderful manner under that covering, like a flower growing ſlowly in its cup; until, after the ſkin is at length caſt, all theſe parts very clearly and diſtinctly preſent themſelves to our view: at that time the veil, if I may be allowed the expreſſion, is at length removed, and all the impediments which till then obſtructed the ſight, and which have produced ſo many errors amongſt all the naturaliſts without exception, is removed, and all is made plain and eaſy. Hence it is, that we can very eaſily exhibit to the eye all the parts which before lay under the ſkin; as I have actually done in the preſence of Thevenot and Magallotti, who accompanied me in theſe experiments, and whoſe teſtimony is ſufficient to put the matter beyond doubt.

We call this change with Ariſtotle, Pliny, and others, the Nymph; becauſe we ſee iſſuing out of it a perfect inſect, fit for propagating its ſpecies, and adorned in all the ſplendour and beauty of its kind, as a virgin in a very rich nuptial garment: the creature having thus paſſed the infantine years of a Worm or Caterpillar, comes forth without delay to meet its fellow of the other ſex in the ſpacious and beautiful tapeſtry of the fields, ſpread for its uſe by nature.

On theſe principles our third order of natural tranſmutations conſiſts; the Worm, after it has caſt off the form of a Nymph, in which it lay without food in its egg, is afterwards increaſed by degrees, and acquires more parts by the help of the food it is ſupplied with, until at length it caſts its ſkin, and attains the form of a ſecond Nymph, which clearly and diſtinctly exhibits all the limbs perfect in all their parts, and is once again deprived of all motion as it was before in the egg: this motion is again reſtored afterwards in a few days by the evaporation of the ſuperfluous moiſture.

Theſe inſects are therefore twice held in the ſtate of a Nymph; that is, firſt in the egg, which is their firſt Nymph; then in the laſt change or ſecond Nymph. But there is this conſiderable difference in the two, that when they are in their firſt Nymph or in the egg, their limbs cannot only be leſs diſtinctly ſeen, than in the ſecond, the reaſon of which we ſhall aſſign hereafter; but alſo that before they are changed into the firſt Nymph or egg, they have no remarkable motion preceding, nor are they increaſed in their limbs in any manner different from other inſects, or from the ſeeds of plants. On the other hand, before they are changed by accretion into the ſecond Nymph, they do not only evidently move themſelves from place to place, but alſo increaſe in the ſame manner as other inſects during their growth, which have the power of moving or going where they pleaſe, and take their food in at their mouths. This being well underſtood, the difference between the firſt change which is called an egg, and the ſecond which we call a Nymph, is very evident; though each of them is only an accretion continued in the limbs though in different manners. We beg the reader will attentively regard what has been hitherto ſaid, becauſe it is of the higheſt uſe, and eradicates entirely the falſe notion of a metamorphoſis or change of one creature into another, that univerſal chimera of erring opinions, and totally deſtroys and ſubverts the monſtrous opinion of a fortuitous generation of creatures.

As the parts of the future inſect are ſeen much more plainly and diſtinctly in ſome of theſe Nymphs than in others, as Ariſtotle, though not perfectly right in this matter, has likewiſe obſerved; we ſhall therefore divide them into two kinds, in order to make the underſtanding of them more diſtinct: that is, we ſhall call one of theſe a Nymph ſimply; and the other the Nymph Chryſalis. Nor ſhall we regard that the word Nymph Chryſalis does not perfectly or exactly expreſs the thing itſelf; and that all the Nymphs, which we call Chryſallides, are not of that gold colour, whence the name: for we have not judged it proper to depart from the received appellations, or to make profeſſed innovations in the terms: ſo far are we from this intent, that our great induſtry and ſtudy are employed to find out truth, and, when found, to explain her ſimply and in her natural ornaments. Hence we have reſolved to perſuade no body to believe more than what may be ſhewn plainly to the eye, and with due attention obſerved by every one, as well as by us, in nature herſelf.

A catalogue of the inſects which belong to the third order or claſs of natural changes, which I call the Nymph.

AMONG theſe inſects which are changed according to the firſt method or ſpecies of the third order, and, by the power of the increaſing and expanding limbs, which breaking open the skin, obtain the form of a Nymph, wherein all the parts appear to be finely and beautifully expreſſed, I firſt reckon Bees. I preſerve in my collection their queen, as ſhe is called; and alſo ſeveral of the drones, which are properly males; and alſo the working Bees, which are of neither maſculine nor feminine ſex; ſince the proper organs neither of male nor female are to be found in them: whereas thoſe organs are very diſtinctly conſpicuous in the queen and in the drones. This queen has been improperly called the king. I diſcovered the egg-bag of the female, or king, as it uſed to be called, in the preſence of the incomparable anatomiſt D. John Van Horne, profeſſor of anatomy and ſurgery; being aſſiſted therein by the ſingular favour of Dr. W. V. Hoorn, a phyſician of Slooten, who readily gave us admittance to his bee-hives.

I likewiſe preſerve the Nymph of the drones, of the queen, and of the working Bees. I can likewiſe exhibit their webs, which are like thoſe of Silk-worms, and alſo the honey-combs; between which are the cells or houſes of the drones and queen, and working Bees, beſides many other things very worthy of obſervation concerning theſe little cells; for I have prepared them different ways, that the moſt artificial order wherewith they are conſtructed might be made evident. I likewiſe keep in my cabinet the ſting of that uſually called the king, and its bag of poiſon; as alſo the bag and the ſting of the working Bees, which I have found to be divided into three parts. In fine, I preſerve alſo in this collection the teſticles and penis of the drones.

It is worthy obſervation in Bees, as well as other inſects, that the lungs are found moſt diſtinctly conſpicuous in them, conſiſting of two white bladders. But in inſects which have blood, and are by that diſtinguiſhed from theſe, the lungs, when cleaned from their humours, are only compoſed of bladders, as the celebrated Marcellus Malpighius has moſt accurately ſhewn: nay, I ſhall ſcarce ſcruple to aſſert the ſame thing of the other viſcera; excepting only that the skin and the other membranes are interwoven with ſmall and ſcarce perceptible cloſed arteries, veins, and the like. Theſe veſſels I have alſo obſerved are ſometimes again opened by the inexplicable power of nature.

The elegant and amazing ſtructure of the reſt of the viſcera in Bees merits the higheſt admiration. But as we ſhall hereafter deſcribe them ſeverally and at large, we ſhall now ſay nothing more on them, for as we here treat only in general of theſe inſects: we can only treat of them in general terms before their particular hiſtory to be hereafter exhibited.

Conſidering however that wonderful republic of Bees, which is founded upon affection only, and excludes all kind of ſuperiority, we cannot but exclaim that nature has concealed in the hiſtory and manners of theſe creatures, treaſures of ineſtimable miracles, which are notwithſtanding freely opened to us, provided we diligently inveſtigate the diſpoſition of thoſe creatures. An unwearied ſcrutiny is the only key to nature; nor is there any other than this, which can open the way into her myſteries.

After the hive Bee, we are to name the Bees that live at large in gardens, fields, and foreſts, and hence are called wild Bees. I preſerve ſix ſpecies of theſe, among which there is one with very long horns; another has an extremely rough hairy body; and a third is extremely like a Waſp: I have exhibited ſome of theſe in their natural ſize, in fig. IV. V. VI. VII. VIII. Tab. XXVI.

I likewiſe reckon in this third order the wood Bees of Aldrovandus, or that called the ſolitary Waſp by Mouffet. Their Nymphs, the web of the Worm, and the Bee itſelf are in my cabinet. I can likewiſe ſhew the little neſts which theſe creatures make of ſmall ſtones, grains of ſand, and dirt. In theſe neſts we ſometimes find a very remarkable Waſp, together with a Beetle, and the Worm out of which the Beetle is produced: nay, that Vermicle or Worm was once in my poſeſſion changed in the exact ſpace of one year into ſuch a Beetle, having had no other food in the mean time but little ſtones and dirt. Theſe obſervations create ſome doubt which of the three beforementioned inſects builds the neſts juſt now mentioned; but to me it appears very certain, that the wood Bee is their architect; for ſhe carries the little ſtones, and the neſt itſelf is found to be appropriated only to her. Such neſts are found in great numbers in the ruins of walls in France.

We might likewiſe mention the Apes Manſuetæ of Mouffet here, but becauſe they belong to our fourth order, and are not Bees but real Flies, we ſhall therefore deſcribe them hereafter in their proper place.

Next follow the Waſps; of theſe I preſerve ſeven kinds, together with the combs, in which ſome of their Nymphs ſtill lie encloſed and ſealed up as it were. I have ſhewn the proboſcis of the common kind of Waſps, in Tab. XVII. fig. VII. the poiſon bladder in Tab. XVIII. fig. IV. and laſtly the ovary, in Tab. XIX. fig. IV. In Tab. XXVI. fig. X. I ex-

I exhibit one of the largeſt kinds of Waſps, and another uncommon kind in fig. II. ibid. to theſe I have finally added, fig. XIV. XV. ſome Waſps of the ſmalleſt kind. I have more than once obſerved, that the Waſps carry the matter whereof they make their neſts upon their legs.

In this order I rank alſo the Pſeudopheca, which we uſually ſee produced out of a Chryſalis, which is underſtood to be corrupted or rotten: I preſerve twenty kinds of theſe in my collection. Hoefnagel has given us delineations of twenty-four; Goedaert likewiſe deſcribed a few. We may properly inſert this kind of Fly in our fourth order, as will appear when we come to that part.

Among the Pſeudophecæ which we keep, is the Muſca Triſeta, or Three-Hair-Tailed-Fly of Mouffet, whereof I preſerve four kinds. I have repreſented one of them in Tab. XXVI. fig. XIII. and ſome ſmaller ones, in Tab. XLIV. and XLV. I preſerve alſo, amongſt the ſaid Pſeudophecæ, the Muſca Uniſeta, or Single-Hair-Fly of Mouffet, indeed two ſpecies thereof, together with the Worm and Nymph; the Chryſalis, which afforded theſe, is likewiſe in my muſeum, from which, when rotten, this Fly has its origin. I preſerve alſo ſeveral other exotic and more uncommon kinds of Pſeudophecæ, of which I ſhall have an opportunity to ſpeak in my particular obſervations.

To this third order, we likewiſe refer the inſect, called by Goedaert, Devorator, or the Devourer. This is that ſpecies of Pſeudophecæ, which kills Spiders, and may therefore be properly called the Ichneumon Waſp. This Waſp ſeems to be ſomewhat of the like diſpoſition with the Muſca Lupus, or Wolf-Fly; for as the former grinds or breaks her food with her teeth, this latter pierces it with her aculeus.

I likewiſe keep in my muſeum the Flies called Panopes, which are deſtructive of grapes, and may properly enough be referred to the genus of Pſeudophecæ. I have found from obſervation, that theſe Flies are not invariably diſpoſed to one kind of food, but will, when they cannot meet with grapes, ſatiate themſelves with any other food they can find.

Next follow the Hornets: I preſerve two ſpecies of theſe, together with the web, which their Worms form; I can alſo exhibit their Nymphs, and the caſes wherein they encloſe thoſe Nymphs. Theſe creatures are ſo voracious, that if they are cut through the middle they will not quit their food, and if that be fluid, I have ſeen them eat while it ran out of the wound; this I have often experienced with a little honey. We exhibit the largeſt ſpecies of Hornets in Tab. XXVI. fig. IX. and one of their cells in Tab. XXIII. fig. XV.

The humble Bee alſo belongs to this order, whereof there are eight ſpecies, among which I preſerve the exotic one with purple wings. In the figures of Hoefnagel there are likewiſe found eight ſpecies. Goedaert has alſo deſcribed the Worm of the humble Bee kind. I have repreſented the neſt of one of them in Tab. XXVI. fig. I. and afterwards one of the Bees of the middle ſize in fig. XII.

Further, I aſcribe the Gnat to this order; this creature is produced in the water, as will be ſhewn in its particular hiſtory; this it might be proper to ſubjoin immediately to the treatiſe of Bees; but as the Nymph of the Rhinoceros Beetle, on account of its remarkable bigneſs and peculiar ſtructure, throws great light on the ſyſtem of this order, we ſhall firſt give a deſcription thereof.

The Muſca Chryſopis, or Golden Eye, I preſerve alſo in my collection, and have two diſtinct ſpecies thereof. Goedaert has likewiſe deſcribed two ſpecies of this elegant inſect.

I likewiſe have the Muſca Florilega, or Flower Fly, which is black, and a great enemy to young flowers; whole armies of this kind ſometimes inſtantaneouſly poſſeſs fields and gardens. They are ſaid to come out of the water, which I ſhould the more eaſily allow, becauſe I know a great many kinds of inſects, which, after having been in the water ſometime, fly out of it at once; thus myriads of the Libellæ, or Dragon-Flies, fly together, at one and the ſame time, out of the water, as do likewiſe Gnats, Ephemeri, and many other ſpecies. On obſerving this, many have erroneouſly perſuaded themſelves that theſe inſects are produced in the air itſelf. But it is particularly worthy of obſervation, that the Ephemerus always dies a little after its birth; whereas, on the contrary, other inſects remain a long time on the earth alive: the reaſons of which difference we have aſſigned in our obſervations on the hiſtory of the Ephemerus.

I likewiſe preſerve the Fly that is like the Butterfly kind, and the Scorpion-Fly, male and female; as alſo the Wolf-Fly, of which I have five ſpecies. The carnivorous Fly, called the Cæſar, is alſo to be found in my muſeum. I can likewiſe exhibit fourteen ſpecies of the common Flies, and twenty-four ſpecies of the more uncommon kind; ſome of theſe have wings adorned as it were with the figures of ſerpents, ſome diſtinguiſhed with faſciæ or wreaths, ſome with ſpots, and others with grooves or furrows, ſome of them alſo have the belly and breaſt variouſly painted with red, green, yellow and gold. We ſee delineated in the figures of Hoefnagel, twenty-five ſpecies of the common, and thirty ſpecies of very rare, Flies; and the induſtrious Goedaert has left us the figures of forty-eight ſpecies of Flies. Hence, when I conſider the great diligence of that naturaliſt, I cannot ſufficiently admire, that he has been always ſo much a ſtranger to the true knowledge of theſe things; but I muſt add that it happened unfortunately, that his thoughts were committed to writing by others; who, mixing their own chimerical notions with his, involved the true knowledge of theſe matters in greater darkneſs.

To this order are likewiſe to be referred ſome very ſmall and uncommon Flies of peculiar origin, ſome of which are produced from the tubercles or warts of willows, Tab. XLIV. fig. v; others ſpring from the alæ or boſoms of the leaves of the willow tree, Tab. XLIV. fig. xv; others iſſue from the roſe willows, Tab. XLIV. fig. xvii; others from downy matter or flocks of the catkins, Tab. XLV. fig. viii; others from the ſtinging nettle, Tab. XLV. fig. v; others from the ſpunge of the dog-roſe, eglantine, or ſweet brier, Tab. XLV. fig. ii; others from the excreſcences of oak, Tab. XLV. fig. xix; and laſtly, others are produced from a kind of Worms that walk with their ſheath or caſe, Tab. XLV. fig. xxxiii. and xxxiv. I have deſcribed all theſe little Flies in the fourth order, becauſe they perform their change in the manner peculiar to that diſtinction.

The Ant likewiſe belongs to this claſs, but as we ſhall treat of this inſect hereafter in our particular obſervations, it may ſuffice to ſay here, that I preſerve both the winged male Ant, and the female, the body of which is ſomewhat thicker; and the labouring Ant, which has no wings, nor does it ſeem to be either of the male or female ſex. It is worthy of obſervation, that this little creature is obliged to carry its young wherever they can have nouriſhment at hand; whereas others, in general, carry the food to their young; other inſects, in a manner different from either of the two former, expoſe their iſſue, as if they were orphans, and oblige them at firſt to find nouriſhment for themſelves. The firſt ſpecies is indeed very induſtrious; the ſecond gentle and good-natured; but the third, unmerciful, and reſembles a cruel ſtepmother. However, the great Creator of them, who does not deſpiſe the cries even of the Raven, Job. xxxix. preſerves them all.

I moreover keep, a thing very wonderful, five hundred and forty-five Flies of one and the ſame ſpecies, which have been likewiſe produced from four Chryſallides of one ſpecies of the diurnal Butterfly; ſo that the life and motion of theſe four creatures ſeems to have tranſmigrated into thoſe of the five hundred and forty-five others. I can ſhew alſo one hundred and eighty-ſeven little Flies, which burſt out of only one Chryſalis that had been wounded. I have likewiſe one hundred and forty-five, ſeventy-ſeven, thirty-nine, and eighteen little Flies of different ſizes, which have been changed into Nymphs, in the bowels of diurnal Butterflies, which belong to ſo many different ſpecies; but I ſhall treat of theſe more accurately in the fourth order.

The Tipula Terreſtris, or Long-legs of the land, belongs alſo to this order, which Aldrovandus deſcribes under the name of the largeſt Gnat, but Mouffet calls it Tipula. There are five ſpecies of this in my muſeum, but Hoefnagel delineates no leſs than ſixteen. This inſect is produced from a Vermicle or Worm which commonly lies under the graſs, and is called by the fiſhermen, in our language, Im or Imme. I preſerve two Nymphs thereof, wherein the parts of the inſect are repreſented tho' ſomewhat obſcurely; ſo that they may be likewiſe referred to the Chyſallides: the difference is not very conſiderable. I likewiſe have a very obſcure delineation of one of theſe Nymphs by Goedaert.

Next in this order follow the Beetles, whereof I preſerve nine of the largeſt kinds, twenty-one of the middling, thirty-ſeven of a ſmaller, and one hundred and thirty-ſix of the leaſt kind. Among theſe there are twenty-five exoticks, brought from the Eaſt and Weſt Indies, Ægypt, Braſil, France, and other parts. Hoefnagel has likewiſe delineated thirty-five ſpecies of the common Beetles, and ſeven more rare and uncommon. We find nineteen ſpecies of the ſmall Beetles deſcribed in Goedaert, to which are added five of their Nymphs, indeed very beautifully delineated. I preſerve likewiſe ſeven Nymphs of Beetles, and among theſe the Scarabæus Naſicornis, or Rhinoceros Beetle.

What deſerves very particular notice in the Beetle, as Fabricius ab Aquapendento has juſtly obſerved, is, that the bones, which in larger creatures which have blood are placed in the inſide, are ſituated on the outſide in the Beetle. And, on the contrary, the fleſh, which lies on the outſide in ſanguiferous animals, is here hedged on the inſide within the bones, or horny ſubſtance of theſe inſects. Another thing which merits the greateſt attention is, that in the very muſcles of theſe little creatures is diſcovered the ſame ſtructure, that the great anatomiſt Nicholas Steno obſerved in thoſe of the larger animals. This is particularly remarkable in the ſtructure of the muſcles of the Locuſt's legs, by the help of which that creature can leap up and down ſo nimbly, that it raiſes itſelf into the air two hundred times the height of its body.

As nature ſhews herſelf wonderful in the ſimilar ſtructure of the muſcles given to theſe two kinds of creatures, ſo indeed does that great immenſe difference, which is between the bones of the larger or ſanguiferous animals, and the horn-like texture of the little bones in inſects. Among theſe inſect tribes, nothing is more various, or can be more worthy of notice, than that exceeding great, and at the ſame time beautiful diverſity of ſtructure, which is to be met with in the horns of the Beetle kind. I really think that according to this diverſity alone the diſtinctions of the Beetles into ſpecies may be determined.

I preſerve ſeven ſpecies of the Scarabæi Naſicornes, or noſe horned Beetles, among which there is one; whereof the horn is bent like a bow, or arch-like, towards the back or ſhoulders. I can ſhew the curious this creature, together with the lice wherewith it is infeſted. But I have obſerved, that it is produced from the largeſt ſpecies of Coſſi or Hexapode Worms *, which are in the exact ſpace of two, and ſome of three, years changed into Nymphs. Beſides this horn upon the noſe, it has two horns which ariſe near the eyes, and terminate as it were in knotty extremities. I ſhall give its whole peculiar hiſtory in its proper place. I preſerve beſides this two other noſe horned Beetles, which are very ſmall, and have the horns divided in a manner into two parts. I can likewiſe ſhew another ſpecies of the unicorn Beetle, which has the horn likewiſe bent like a bow or arch towards the breaſt, and ſerrated on the inner part with four teeth: whilſt in the mean time the bony coverings of the ſhoulder, loins, and breaſt, are ſtretched vaſtly forward, and terminated in this horn, which is planted in the concave part of its arch with briſtly hairs, of a gold colour, and ſoft like velvet. I have likewiſe two other noſe horned Beetles, which have the horns undivided in their originations, but afterwards terminate in ſplit points. In theſe Beetles the breaſt bone is likewiſe black, horny and divided, and terminates in one of their horns, which is as it were ſerrated at one end; but at the other divides itſelf into two obtuſe horns. The laſt named ſpecies of the Beetle is alſo adorned with very ſingular and knotty horns placed near the eyes. I exhibit alſo five ſpecies of theſe exotic Naſicornes, or noſe horned Beetles, of their natural ſize, in Tab. XXX. fig. 2, 3, 4, 5, and 6. The largeſt Beetle that I have in my collection, is, together with its horn, ſix inches long, and its body half an inch broad: if its wings be expanded, they meaſure ſeven inches.

I preſerve with theſe in my cabinet, the Beetle called the flying Stag, or flying Bull; the Lucanus, or Stag-horned Beetle, the male whereof is horned, but the female, as is commonly aſſerted, has no horns. It is very remarkable in this as well as in the other inſects of this kind, that their wings are hidden and folded as it were within little ſheaths, from whence they have obtained the name of vaginipennæ, or ſheath-winged. We likewiſe obſerve when theſe inſects fly, that theſe little ſheaths, or caſes, wherewith the wings are at at other times covered, are only elevated, and are not agitated by the motion in flying. There is nothing in this flying Stag more worthy of notice, than the proboſcis or trunk wherewith its ſwallows its food: this food is a juice like honey, oozing out of the oak. This trunk is delineated among the figures of Hoefnagel, which are indeed the beſt and moſt accurate of all the figures I have hitherto ſeen. I can exhibit the method whereby the wings lie folded under the outer pair beforementioned; we are not to ſay they are in reality plaited, for they are rather contracted by the aſſiſtance of joints. I have obſerved that theſe joints are placed almoſt in the extremities of the wings, and are moved by the help of peculiar muſcles; hence a fluid likewiſe drops from them when they are wounded, which is not the caſe when wings are merely membranous. When I offered a little honey on the point of a knife to one of theſe Beetles, it followed me like a dog, and ſucked the honey very greedily with its trunk.

Beſides theſe, I can likewiſe ſhew twenty-one ſpecies of the Capricorn Beetles. Theſe creatures have all wonderfully long horns. Some of theſe which I preſerve are furniſhed with branching and prickly horns with knotty and ſhort joints; and the horns of others are divided into very long, equal, and as it were knotleſs joints, ſome of them are ſomewhat ſituated in the middle, and are knotty again where they are joined to each other. The body of the largeſt Capricorn Beetle I have is above four inches and an half long, and the horns are as long as the body. I have likewiſe another above two inches long, which is covered with prominent party-coloured hairs like a Turkiſh carpeting, and makes a wonderfully beautiful figure: its fore legs are much longer than the reſt. Moreover, I have a ſpecies of theſe flying Capricorn Beetles, which has very tender legs and horns; which, however, are conſiderably thick about the bending of the joints, and where the muſcles are inſerted. I have likewiſe a Waſp with this kind of knotty joints.

With theſe I preſerve ſeventeen of the flying Capricorns with much ſhorter horns. Among theſe there is a kind of Beetle, that vibrates its wings with ſo much velocity, that it is with very great difficulty to be taken, and hence we have called it the flying Beetle. A thing extremely wonderful in this Beetle is, that its teeth are on the inſide full of ramifications, by which ſtructure it is indeed diſtinguiſhed from all others. This Beetle flies in the day-time, and is the ſame with the fourth and uncommon ſpecies of the Stag Beetle of Mouffet.

I have moreover nine ſpecies of the ſaid flying Capricorns, having ſtill ſhorter and ſmaller horns.

I likewiſe inſert the Cicindula or Glow-Worm, which is of the Beetle kind, in this order. It indeed reſembles a flying diamond or little ſtar; it glitters with as much light, when it is yet a Worm with ſix legs, as when it is changed into a perfect Beetle: in that ſtate it muſt firſt elevate the ſheaths or caſes of its wings, or at leaſt ſtretch out its tail or the extremity of its abdomen, in order to diſcloſe its light.

Laſtly, among my Beetles are thirty-two ſpecies, furniſhed with horns that have knobs at the tops of them. Theſe globules of the horns are indeed conſtructed in a moſt wonderful manner, for ſome of them reſemble bunches of grapes, others are like the leaves of an open

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* As all Butterflies are produced from Caterpillars, all Beetles are produced from Hexapode Worms. Some of theſe live on land, ſome in water; but they are in general all longer lived creatures than Caterpillars.

book, and others again are of various different ſtructures. One may by the help of theſe horns very eaſily diſtinguiſh the male from the female. This is likewiſe the caſe in the nocturnal or night Butterflies, for their males may by this ſign be very eaſily diſtinguiſhed from their females, while they are ſtill in the Nymph ſtate. Of theſe ſpecies of Beetles ſome are oblong, others round, others ſhort, others indented, ſerrated, party coloured, or variegated and ſprinkled over as it were with duſt or meal, rough with ſmall tubercles, ſquares or cheques, or conſpicuous by their ſpots and various other ornaments. Among theſe I can likewiſe ſhew a Beetle found in the neſts of wild Bees, and delineated in Tab. XXVI. fig. III. Almoſt all theſe Beetles fly at night.

I refer alſo to this order the common dung Beetle, which has its horns terminated by knobs. I have two ſpecies of this, which, like the blue black Beetles, emit a bright and glowing light; one of them is conſpicuous by a purpliſh gloſs, like that of copper, on its breaſt and belly: the other glitters like green molten braſs or copper delicately gilt, and indeed makes a very beautiful figure.

I have moreover four ſpecies of the Bupreſtes, or green, gold, and yellow Beetles, which are of an offenſive ſmell; the horns of theſe are formed like thoſe of the Capricorn Beetles, and the males are ſmaller than the females. I have likewiſe another ſpecies which ſmells like a roſe.

I keep alſo four ſpecies of the Cantharides, to which I think the former in reſpect to their qualities and virtue are nearly related. I have likewiſe the eggs of the common golden yellow Beetle, which are like mother-of-pearl. Some of theſe inſects have knotty horns, and others have them formed like thoſe of the Capricorn Beetle. Among theſe I can ſhew a very beautiful Beetle, the body of which is adorned with little apertures and impreſſed furrows. This was given me by the very celebrated Dr. William Piſo, formerly principal phyſician to his highneſs prince Maurice of Naſſau.

I can likewiſe ſhew the Indian Beetle, the ſheaths or caſes of whoſe wings are of a ſhining black like ebony, and have many little indentings, wherein are ſeen little oblong feathers adorned with all kinds of colours, bright as any kind of gems whatſoever.

I likewiſe reckon the Curculio or Weavil in this order; which, from a Worm deſtructive to corn, is changed into a Beetle, and of which a magnified delineation may be ſeen in Redi. Aldrovandus deſcribes a Weavil which is changed into a Butterfly, and indeed belongs to the ſame order, but to the third ſpecies of it.

I preſerve alſo ſix ſpecies of Beetles with long necks and Hogs noſes, which I therefore call flying Hogs, or Hog Beetles.

Next follows the Proſcarabæus, Vermiculus, Majalis, or May-Worm, which, as well as others we likewiſe think referrable to this order. We have three ſpecies thereof, two of which have horns like thoſe of the Capricorn Beetles; but thoſe of the third are knotty. Goedaert has likewiſe deſcribed a Vermicle as belonging to the laſt, but he has very prepoſterouſly joined them together.

To theſe I add the Staphilinus, which, ſeeming of a middle nature between the Beetle and Scolopendra, can very quickly kill Earthworms with its teeth, and afterwards ſuck them. Goedaert has committed three errors concerning this inſect, which we ſhall hereafter explain and ſet right. This inſect and the Worm from which it is produced are likewiſe deſcribed by Mouffet. I preſerve five ſpecies of it, together with the Worm and Nymph, which exhibits the parts of the future inſects but ſomewhat obſcurely. Theſe inſects have horns like thoſe of Capricorn Beetles, but their wings are complicated in a very uncommon manner.

I preſerve beſide theſe four ſpecies of Beetles, which, whether they lie on their back or belly, can contract and preſs their head and breaſt cloſe to the ground, and jump into the air: wherefore we think that the name of Graſshopper or Locuſt Beetle is a proper one for them.

I have likewiſe the ſmall Beetle, which, having firmly and ſtrongly fixed its foremoſt legs, and bent and put its head through the ſpace between them, makes a continual noiſe in old pieces of wood, walls and cielings, which is ſometimes ſo loud, that, upon hearing it, people have been perſuaded that nocturnal hobgoblins, ghoſts, or fairies wandered about them. I think that this may be properly called Sonicephalus, or the noiſy-headed Beetle. Other ſpecies of Beetles make a ſtrange noiſe by rubbing their head againſt their breaſt, and others preſs their tail or belly cloſe to the ſheaths or caſes of their wings, and by that means make alſo an uncommon creaking.

I have alſo four ſpecies of the Scarabæi Teſtudinati, or Tortoiſe Beetles, and ſome of their Worms and Nymphs. Goedaert has likewiſe deſcribed two ſpecies of theſe.

I alſo have the Scarabæus Aculeatus or ſtinging Beetle, with its tail formed like an aculeus or ſting, which is not met with in any other of the Beetle kind.

Moreover, I can ſhew a very ſmall Beetle with its Nymph, which is produced out of a Worm without legs, and is found hid within the outer ſkin of the leaf of the ſallow tree. This Worm has its food there ready and ſufficient for it, until it is at length changed into a perfect Nymph in all its parts. I have deſcribed the whole change of this Beetle, which is carried on very obſcurely, in the fourth order, and have exhibited its figures in Tab. XLIV. fig. XII. XIII, &c.

I have moreover a deteſtable Beetle, produced from a Worm that eats the roots of ginſeng, and is changed into a Nymph within that precious drug. The ſame is likewiſe found in old logs of wood.

I likewiſe keep thoſe Beetles, with their Nymphs, which are produced from Worms that gnaw dried fleſh. By the aſſiſtance of theſe Worms a ſkeleton may be eaſily cleared of the fleſh that ſticks to it.

I am alſo to add that I have a Beetle, the Worms of which eat the bag of the muſk; I have, on account of the obſcure manner of its changing, deſcribed it under the fourth order, and given its figure in Tab. XLV. fig. XXXII.

Laſtly, I rank in this order the largeſt, the middling, and the ſmalleſt Hydrocanthari, or Water Beetles, concerning which I have occaſionally inſerted various obſervations of the greateſt importance to the naturaliſt. I preſerve five ſpecies of theſe; the ſmalleſt is called the common water Flea, and water Fæmella. When this dives under the water, it has the art to encloſe a little bubble of air very dexterouſly in its tail. I have repreſented the parts of generation of the Hydrocantharus, in Tab. XXII. fig. V. and the Worm called Vermis Sicarius, out of which it is probably produced, is exhibited in Tab. XXIX. fig. IV. and V.

The third order or claſs of natural changes, according to the firſt ſpecies or method, which we have called ſimply the Nymph, exemplified in the Ant.

Tab. XVI.

No. I. THE Ant's egg delineated in its natural ſize, or the Worm of the Ant in its firſt ſkin or coat, wherein it is called the egg. The firſt of theſe figures exhibits it magnified.

II. Is the ſkin beforementioned after it is caſt. This is a kind of thin membrane, which the Vermicle or Worm of the Ant, quitting the form of an egg, throws off looſely, and rolls up as into an imperceptible point.

III. The Ant's Vermicle or Worm, imperfect in many of its parts, without legs, come out of its egg or ſkin, and here repreſented in the form wherein it is commonly found in the earth at that period; that is, having its head bent towards its breaſt. Figure II. exhibits a microſcopic view of it.

IV. The Ant's Vermicle or Worm having attained its full bigneſs; that is, when all the limbs and parts proper to the Ant are already increaſed under the ſkin, but ſtill lie hidden. Figure III. gives it as ſeen under the microſcope.

V. The former Vermicle or Worm, having caſt its ſkin and expoſing to view all its parts, which were before hidden; It ſhould therefore be now called a real Nymph, whoſe limbs are ſwollen with a fluid matter, as will be made more evident in the explanation of the fourth, fifth, and ſixth figures, which exhibit the ſame ſtate of the creature magnified, together with its ſeveral parts.

VI. The ſame Worm now come into the ſtate of the Formica or Ant, as will be more accurately and largely deſcribed in the ſubſequent explanations of the figures.

Tab. XVI. Fig. I.

The Ant's egg magnified, perfectly ſmooth and equal, diſtended, glittering, and without any annular diviſions. This is naturally ſo ſmall that when placed on a black ground it is ſcarce viſible to the naked eye. This muſt be well obſerved in order to diſtinguiſh the true or real egg of the Ant.

Fig. II.

The Vermicle or Worm of the Ant delineated larger, and preſenting its head and mouth, together with the twelve annular diviſions of its body. The head is bent towards the breaſt; and if the Worm be touched or moved in the leaſt, it always contracts itſelf in that manner. Though this be a real Vermicle, yet it is commonly called the egg of the Ant. But this appellation proceeds from the groſſeſt ignorance, ſince it palpably is a real creature, having life and motion, though it is yet without legs: it does not bear the leaſt reſemblance to an egg, nay it is ſometimes larger than the Ant itſelf. But ſuch is the ignorance of thoſe perſons who ſeek for theſe Vermicles and expoſe them to ſale in the market: they are bought there in order to be given as food to various kinds of birds, and they are very greedily eaten by them.

Fig. III.

I here exhibit the method whereby the Vermicle or Worm beforementioned leiſurely and quietly undergoes its natural change; the blood and other humours inſenſibly ſwelling about the breaſt and near the head, and by that means the creature itſelf becoming thicker, larger, and more ſwollen: by this means at length loſes all its motion, that is when it has caſt its ſkin, and brought to light its limbs, that were before hidden.

Fig. IV.

The ſame Vermicle or Worm, having caſt its firſt ſkin, and preſenting to view all its limbs and parts, which were before hidden under the ſkin; hence it is in this ſtate called a Nymph, which I repreſent magnified, and reclining on its ſide.

Fig. V.

The ſame Vermicle, lying on its back, is in this figure expreſſed magnified.

Fig. vi.

The ſame Vermicle or Worm is here again exhibited, and all its members are diſtinguiſhed by letters annexed: hence it is indeed very evident that the Nymph is the real inſect, but ſtill deſtitute of motion in its limbs. This it enjoys, when it acquires the perfect form of the inſect which it now repreſents.

a a, The two eyes in the head.

b, The teeth.

c c, The horns, which are folded near the legs upon the breaſt.

d d, The firſt pair of legs folded under the horns.

e e, The ſecond pair, conſpicuous under the firſt.

f f, The third pair, which are laid on the belly.

It is likewiſe ſeen in what manner, all the ſtrong joints of theſe ſix legs are laid on the breaſt between the horns.

g, The annuli or rings of the abdomen, together with the margin or border on each ſide. But this is more manifeſt in the fourth figure, wherein that margin or verge, as well as the little ſwellings of the loins, are more diſtinctly exhibited, and at the ſame time it is ſeen how the body is all folded up and bent.

The creature in this form is, as I have obſerved before, the real Nymph of the third order, according to the firſt ſpecies or method of transformation, which clearly and diſtinctly exhibits all its parts and limbs without exception, ſo that all thoſe parts may be ſeen in it, which are afterwards found in the common labouring Ant, whoſe Nymph it now properly is. This Nymph is therefore the Ant, and the Ant is a Nymph, but the Ant hitherto lies as it were hid under a peculiar diſpoſition of its limbs; and this is the principal difference.

When this Vermicle or little creature caſt its skin for the laſt time, then all its limbs and parts are very white like curdled milk, and are fluid as water; ſo that under this form it ought to be conſidered as if it lay yet in its egg, ſince it is there diſpoſed in the very ſame manner, and is as properly a Nymph. The only difference is, that in the egg its limbs, though certainly exiſtent, are not viſible; though on the contrary they manifeſtly appear, when it is a ſecond time reduced to this condition, ſo like that of an egg. Hence this little creature is twice, as it were, a fœtus, twice in its egg-ſtate, and twice hatched or born. But the life it leads is not in all its circumſtances the ſame; it differs indeed very much, for it appears in the firſt ſtate like a poor and miſerable Worm; but the ſecond time, which is in ſome meaſure its renewal and regeneration, it is formed into a perfect creature. This proceſs is formed in ſo remarkable a manner in Butterflies, that we ſee therein the reſurrection painted before our eyes, and exemplified ſo as to be examined by our hands; hence the Italian poet ſaid moſt truly,

Non v'accorgete voi, che noi ſiam vermi,
Nati a formar l'angelica Farfalla.

That is,

Doſt thou not know we Worms are born,
Angelic Butterflies to form?

We muſt further obſerve, that the writers of natural hiſtory ancient and modern, Ariſtotle, Mouffet, Harvey and others, who have called this change in the Aurelia an egg, have not wandered entirely out of the path of reaſon, provided their words be taken in the ſenſe now mentioned. I would however have it obſerved, that they muſt be ſaid to have really deviated from the truth, in that they have not annexed the ſignification mentioned in this place to their Aurelian egg, but have propoſed it as a real and ſimple egg, without any reſpect to the eſſential parts. This cannot totally be overlooked by thoſe, who labour cautiouſly to inveſtigate the natural changes in the inſect tribe.

The head, the breaſt, the belly, and the reſt of the parts of this inſect are inveſted with a thin kind of membrane, and are ſo very cloſely ſurrounded by it on every ſide, that even the extremity of the eyes, horns, teeth, and legs, are encloſed in it, together with the reſt. However theſe lie in a looſe manner over each other, nor are they united or connected to one another by an uniform cutaneous cruſt, as is the caſe in a particular manner in Butterflies. The membrane, which encloſes the parts of the Nymph of the Ant is not every where of equal thickneſs, indeed leaſt of all where the limbs are cloſe or applied to the body near the breaſt; but where they are not ſo cloſely laid together, as in the extremities of the legs and horns, there the inveſting membrane is equally thick in all its parts. This is very ſeldom obſerved in the Aurelia, nor have I ever ſeen more than one example thereof in the Chryſalis of the ſwift Butterfly, the trunk of which is in part diſtant from the body; for there the inveſting membrane is obſerved to be every where equally thick, as may be ſeen among the figures of the Rhinoceros Beetles, in Tab. XXIX. But this is uncommon in Chryſallides, though it is conſtantly the caſe in Nymphs.

Paſſing theſe conſiderations over, it is manifeſtly evident from hence, that between the limbs, which are ſeen and repreſented in the Ant's Nymph, and thoſe which appear in the Ant itſelf, there is no other difference, than that the appearance of the parts is ſomewhat more evident and plain in the Ant, but in the Nymph ſomewhat obſcure. We muſt obſerve that the ſame thing holds equally in the Ant's Vermicle or Worm, which hides the limbs and parts under the skin that is not yet caſt off. For in reality the egg, Worm, Nymph, and Ant, are all but one and the ſame creature variouſly cloathed, and lying under different yet accidental forms. Therefore the Ant, that I may expreſs the buſineſs with ſufficient accuracy, is covered or ſurrounded in the beginning, when it is an egg, with an oval or ſpheroidal skin; and afterwards, when it appears under the form of a Vermicle or Worm, is covered with an annular and hairy skin; and thirdly, when it is a Nymph, and is found wrapped up in a divided and articulated veil; until, fourthly, it at length caſts this skin, and afterwards retains this its laſt form, wherein it is a perfect inſect, ſtript of all its integuments; is ſtill the ſame Ant, in this variety of appearances: ſo that having thus, at certain diſtances and ſtated times, caſt off all theſe coverings, the creature is perfect, and is never changed more. This muſt be in the ſame manner underſtood of all other Vermicles or Worms which have no legs; nay, of thoſe alſo which have legs, that is, of ſuch as ſo long and ſo often change their skin, until at length they no longer change their form, but become perfect inſects, afterwards procreating their ſpecies in the ſame order.

When this Nymph caſts its laſt skin, many remarkable changes are obſerved; the eyes are altered in the head by a ſlow accretion, and change colour from white to black; the horns, the legs, and the reſt of the body; are more and more diſcoloured; a ſuperfluous moiſture is exhaled from all the parts, the limbs, which were till now without ſtrength and motion, begin to move, and at laſt the inveſting skin is diſengaged from all thoſe parts; and then, and not before, this Nymph is called an Ant.

Fig. vii.

In this figure the Ant is repreſented under that form in which it ſhews itſelf when it has caſt the laſt skin. All the obſtacles which impeded the ſight in examining its parts, are now removed. Hence we may ſee the Ant no longer covered or veiled but in its real form; nor is it after this laſt operation, during its whole life, further augmented or changed; as it has attained its full maturity and the greateſt ſtrength of life. The ſame thing likewiſe is found in the ſame manner in all other inſects ſubject to theſe changes, for none of them are ever increaſed or changed, after having caſt the laſt skin. Hence, doubtleſs, the reaſon may be aſſigned, why we ſee theſe inſects never become larger in other countries than in our own, unleſs they are of a different ſpecies; or are ſuch as eat ſomewhat more plentifully, while they are in the form of Worms and Caterpillars; for by this means their bodies may become ſomething, though not much, larger than uſual, as we have ſhewn elſewhere.

By the power of inſenſible perſpiration, the Ant's skin after all theſe changes is grown very hard, and becomes as it were horny, though it was ſome weeks before the laſt transformation, tender and fluid like water, ſo that the creature could not ſtir one of its parts with even the leaſt motion. In the more conſpicuous, that is, in the larger Nymphs belonging to larger inſects, this change is ſtill more conſiderable than in the Ant's Nymph: for their ſkin which was in the beginning of the change likewiſe very ſoft and tender, becomes in a few days horny and as it were bony, as ſhall be hereafter explained in its proper place in the Nymph of the noſe-horn Beetle, which likewiſe belongs to this order.

It will be now proper that we exhibit in figures the limbs and parts of the Ant, in the ſame manner in the Ant itſelf, as we have before ſhewed them in its Nymph. To this purpoſe I have allotted this ſeventh figure, wherein I repreſent the common labouring Ant, ſuch as is uſually found in the gardens and paſtures all over Holland and elſewhere. I here delineate the Ant magnified in ſuch a manner, as it very cautiouſly carries the Worm or Vermicle in its mouth, or between its two teeth, without the leaſt danger of hurting it, Tab. XVI. fig. vii. *a*. Theſe teeth of which the Ant has only two, are more properly jaws, an upper and a lower, which hang crooked or bent on the outſide of the mouth, and have ſeven ſerrated inciſions or diviſions, ſerving as ſo many particular teeth. This may be clearly ſeen in Tab. XVI. fig. xi. at the letter *a*. Moreover, the diviſions of the head, breaſt and belly may be diſtinguiſhed in this ſtate much more accurately than in the Nymph. The eyes are very black, Tab. XVI. fig. vii. *b b*, the antennæ or horns under the eyes are of a faint red colour *cc*, and are compoſed of twelve horny joints; the firſt of which, that immediately under the eyes, is very long: but all theſe joints are covered or ſurrounded by briſtly hairs. It is likewiſe ſhewn very diſtinctly here what form and ſtructure the head and thorax are of, and that they are inveſted with a horny, ſtriated or furrowed, crooked, and indented ſkin. This ſkin reſembles the fibrous joints of the wild pines, when they are cleaved or cut, where it is knotty. The conſtruction of this furrowed ſkin is ſeen yet plainer in the Ant exhibited in fig. xi. The inciſions of the thorax, fig. vii. *d*, are divided into ſix ſharp-pointed prominences, which become more conſpicuous backwards towards the loins. The loins themſelves conſiſt of three knotty vertebræ or joints *e*, and are every where ſet thick with briſtly hairs. Underneath at the thorax are ſeen ſtrong hairy legs *ff*, each compoſed of four joints; the laſt of which, or that properly called the foot, is divided again into ſmaller joints, and the laſt of theſe is armed with two claws.

The abdomen or belly, the colour whereof is ſomewhat more red than the reſt of the body; this being of a light red, ſhines like a looking-glaſs, and is ſurrounded with briſtly hairs *g*. I call this creature I have been deſcribing the working Ant; nor do I think it is provided with either male or female organs, as I ſhall demonſtrate to be the caſe in the Bees; ſince it ſeems to be deſigned by the moſt wiſe Creator for labour only, and to carry, remove, preſerve and nouriſh the young of the others.

Fig. viii.

To make this hiſtory of the Ant as complete as in my power, I have here likewiſe delineated the male Ant in its natural ſize.

Fig. ix.

I delineate the ſame magnified in this figure, both becauſe the limbs of this creature may be the more conveniently deſcribed, and that the differences as well as agreements between one Ant and another may be the clearer or more evidently explained.

It appears then that the teeth *a* and antennæ or horns *cc*, are in this, in every reſpect, like thoſe of the working Ant; only that the teeth in the males are ſomewhat leſs than in the working kind: and this is likewiſe obſerved in the female Ant. Something like this is alſo ſeen in the teeth of male Bees. The eyes in the male Ant are much larger *bb*, and ſurpaſs thoſe of the working and female Ant; and this holds likewiſe in the males of Bees, Ephemeri, and other inſects.

Beſides theſe, three points or dots like mother of pearl are in this ſeen in the head; which I have likewiſe obſerved in Bees and Flies. They are indeed remarkable eyes of a diſtinct kind from the others, and make a peculiar difference between this male and the working Ant: but there is ſtill a greater difference in reſpect to the breaſt, for beſides that it is in this diſpoſed and painted in a quite different manner, there are alſo four wings *dd* very conſpicuous on it, whereof the two firſt are nearly twice as large and ſtrong as the two hinder ones. The ſtructure of the loins *e* and belly *f* is likewiſe very different from that of the working Ants: and the whole body of the male is larger, and of a darker colour; as is likewiſe the caſe in the males of Bees.

Theſe males of the Ants, which differ in reſpect to their Nymphs from the two other kinds, the latter having their wings regularly diſpoſed and folded, are not to be found at all times of the year among the ſwarms: hence it is probable that the working Ants kill them, when the buſineſs of generation is performed. The Bees we know act in this manner by their males, which are called drones. And this is probably the reaſon why the males are ſo frequently ill treated by the working Ants, as I have often ſeen.

Theſe males of the Ants regard nothing but generation, and therefore are admitted into that republic only for this ſingle purpoſe, to propagate their ſpecies. The ſame thing exactly happens among Bees, with whom the Ants have indeed many things in common; there is no ſuperiority or pre-eminence among either Bees or Ants; love and unanimity, more powerful than puniſhment or death itſelf, preſide there, and all live together in the ſame manner as the primitive chriſtians anciently did, who were connected by fraternal love, and had all things in common.

Fig. x.

I here exhibit the female Ant in its natural ſize.

Fig. xi.

The female Ant is here again repreſented magnified. She is naturally not only longer than the working Ants and males, but alſo much more bulky and corpulent: it is eaſy to diſcover by diſſection very ſmall, white, oval eggs in her. She has likewiſe teeth *a*, eyes *bb*, and horns *cc* like the former; and in the hinder part of the head towards the neck, ſhe is furniſhed alſo with three ſmall eyes, like mother of pearl; ſo that in this reſpect, the female remarkably differs from the working Ant, and is partaker of the privileges and benefis of the male. The female Ant is likewiſe diſtinguiſhed from the two former kinds, in reſpect to the ſtructure and form of the thorax *d*; this part in her being ſomewhat browner than that of the working Ant, and ſomewhat redder than that of the male. There is ſcarce any difference in the legs *ee*, or in the feet *f*, nor about the belly *g*, only that this is larger becauſe of the eggs that are to be lodged therein: all this is evident in the figures. Whether all the ſpecies of Ants are ſo conſtituted as to have in each community a great many working ones, ſome males and ſome females, I cannot of a certainty affirm. I am however poſitive, from my own obſervations, that this is the caſe in the moſt common ſpecies of Ants, which are found in the fields and vineyards in Holland and about Amſterdam; for I have there frequently taken them out of the ground, and from among the roots of the graſs, and brought them to my chamber and kept them alive by proper food to complete my obſervations.

To do this I uſed the following method: I provided a large deep earthen veſſel, and about ſix inches from the brim or verge of it, I put a bank or artificial rim of wax, and then on the outſide of the circumference of this I poured water, in order to prevent the Ants confined in this encloſure from getting out. I afterwards filled the cavity of this diſh with earth, and therein placed my little republic of Ants. It happened that in a few days the Ants laid their eggs in this veſſel: from which were produced thoſe Vermicles or Worms, erroneouſly called by the vulgar, eggs, which I have before deſcribed. It cannot indeed be expreſſed in words, with what induſtry and ſolicitude theſe working

Ants take care of the young ones, and with what love they feed them: they carry them with amazing fondneſs between their jaws from place to place, nor do they omit any thing neceſſary for their ſupport or nouriſhment.

When the earth wherein they lived grew dry, I obſerved that they carried their young ones to a lower part and deeper under the ſurface; but when I poured a little water thereon, ſo that the mould became moiſt, it was then wonderful to ſee how they all, ſtimulated with love, endeavoured as much as they could to take away their young and carry them to a dry place. Nay, I obſerved that after I had poured in a greater quantity of water, they with all their might carried them to the higheſt part of all. If I only moiſtened the dry earth, then they likewiſe carried their young out of the damp part. Thus I had opportunities to ſee very diſtinctly, that the young ones moved and ſucked nouriſhment out of the fine and ſmall particles of the earth.

I often endeavoured to nouriſh theſe young Worms, without the aſſiſtance of the working Ants, but I never ſucceeded. Nay, I could not exclude even the Nymph of thoſe Vermicles, which the Ants likewiſe carry daily from place to place, without the aſſiſtance of the working Ants. I gave them ſugar, raiſins, apples, pears, and the fruit of other trees and plants. I never found that they built thoſe artificial neſts mentioned by ſome authors, and therefore I apprehend that is to be underſtood of ſome other ſpecies. Even in thoſe places which they ſpontaneouſly inhabited, I never diſcovered any work of art performed by the Ants of this ſpecies; only broad paſſages and crooked ways, deſigned for carrying their young from one place to another. I have obſerved likewiſe that they follow the ſun's motion, and convey their young according to the courſe that luminary purſues: this I have obſerved in the fields where they inhabit little hillocks of earth; for they there carried their young conſtantly to thoſe parts where the ground was warmed with the ſun's rays. I never obſerved that Ants provide themſelves any food for the winter, although this has been ſo ſtrongly aſſerted: and therefore I think they eat nothing whilſt the winter is ſevere; as is common with many inſects, and in particular with ſome ſpecies of Bees, which in the midſt of winter abſtain from all kinds of food [*].

Of certain other kinds of Ants, ſome of which ſpin like the Silk-worms.

BESIDES the ſpecies of Ants hitherto deſcribed, I have ſeen five other kinds, ſome of which I preſerve in my collection. The firſt ſpecies is very large, and was brought from the Cape of Good Hope. I have delineated it in Tab. XVI. fig. XVI. of its natural ſize. Its head, eyes, horns, teeth, breaſt, legs and belly are ſeen there as they naturally are. It is of a bright red colour: but whether this was the working Ant or the female of that ſpecies, I could not diſcern: as it had no wings I am certain it was not a male. I am likewiſe ignorant of the diſpoſition and nature of this ſpecies of Ants.

The other ſpecies of Ants, which I have ſeen in Holland, is fleſh coloured, and of ſuch ſize and form as is expreſſed in fig. XIV; but I cannot now determine whether this was a working Ant or a female. I met with this ſpecies at Honteſlard; where I examined in a wooden bole its eggs, Vermicles, Nymphs, working Ants, females and males, in great numbers mixed together in ſome mould, where they were ſet in order to ſerve ſome birds for food. The males exceeded ſomewhat in bigneſs the Ant I expreſſed in the figure, and had four membranaceous wings. But what deſerved particular notice in this ſpecies was, that the Nymphs were all encloſed in a ſheath or caſe, which, when the working Ants carefully preſerved, carried here and there between their jaws, made a very agreeable figure; for thoſe Ants carried on this occaſion a bag bigger than themſelves. I experienced then for the firſt time that the Vermicles of Ants, as well as the Silk-worms, form a bag or follicle, and that thoſe that are encloſed in it are changed into Nymphs. This web was of an oblong oval figure, and wrought with delicate and fine threads about the body, being of a ruſty iron-colour, and when I opened it, I found a Nymph in the inſide. I likewiſe carried ſome of theſe encloſed Nymphs with me to Amſterdam, which after ſome days gnawed their way out of their webs, and produced ſome male Ants: this happened on the eighteenth of July. I gave the figure of ſuch a ſheath or caſe entire, and in its natural ſize in figure XII. and a ſection thereof in fig. XIII.

The third ſpecies of Ants that I obſerved, was ſomewhat leſs than the common Holland Ant: this does not ſpin. I have given the hiſtory thereof at large. Its body was much blacker and brighter than any of the other ſpecies. I found theſe Ants running on ſome willow-trees, and they ſeemed to live only there. But I have not been hitherto able to ſee their males.

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[*] Our author is not ſingle in his opinion that Ants do not eat in winter; Leewenhoeck appears to be of the ſame mind, and imagines that they ſpend that ſeaſon, like Dormice and many other ſorts of animals, in a ſtate of ſleep; and this ſeems to be reaſonable, as Ants are obſerved to move more ſlowly as the cold weather advances. Mr. Gould alſo agrees with Swammerdam that the Ants do not make any proviſion for winter. But though our author here did not obſerve any ſuch proviſion to be made by thoſe he examined, yet probably ſome other ſpecies may, and other naturaliſts tells us very wonderful things on this ſubject; and further, this opinion of their providing for winter ſeems to be countenanced by the royal and inſpired naturaliſt, Prov. vi. 6, 7, 8. However, if it be true that they remain in a ſtate of reſt during the winter, the proviſion they make may be for their young, for whom their affection is wonderfully remarkable.

The fourth ſpecies was again leſs, but of a thicker and more reddiſh body; nor have I ever found its males. The fifth ſpecies was of a more ſlender, and at the ſame time ſomewhat longer body than the fourth: I ſaw the males of this with four wings. The ſixth ſpecies that I obſerved was wonderfully ſmall; it was of a bright red colour, had two eyes, two horns, two jaws, and ſix legs; and it was, like the reſt, divided regularly into a head, thorax, and belly. I have not yet ſeen the males of this ſpecies; and therefore I only repreſent the working Ant belonging to it in its natural ſize in figure XV. Theſe little Ants are ſeen only about the middle of the month of July; but then ſome hundreds appeared, and they yearly at ſtated times infeſted the cheeſe-loft and pantry, notwithſtanding all our endeavours to drive them away. After October not one of them was to be ſeen until the next year. It ſeemed to us that they came out of a wine-cellar, and crept through the ſmall clefts between the beams and timber planks to the place where they could find food. This, which was firſt conjecture, we afterwards found to be true; for when the cellar had been kept full of water for ſome months, we never afterwards perceived any Ants.

What merits particular regard in this hiſtory is, that theſe Ants remained ſo long as to the middle of July in the earth and ſand, and then firſt came in ſight; but after October all of them betook themſelves again to their little cells. Whether they lived in the mean time without food, or whether, as is common with many inſects, the old ones died, and young ones were produced out of the remaining eggs and Nymphs, I cannot determine: but from the analogy of other inſects I can eaſily judge that the manner of theſe creatures living was very ſingular and uncommon. Beſides, it is probable that the males of theſe Ants were deſtitute of wings, ſince I have for ſome years made my obſervations on them, but could never find any whatſoever that had wings. I would not, however, aver this for truth; becauſe nature is wonderfully conſiſtent with herſelf in all her works. Dr. Padbrugge has informed me that he alſo obſerved many ſpecies of Ants in the Eaſt-Indies; and particularly that there were white Ants there, leſs than the common Dutch ones; and that they were very deſtructive of food and ſome kinds of merchandiſe. I have this year received from the ſame gentleman a very beautiful figure of the black ſpotted red Ant, which he ſent me from the iſland of Ternate: it is ſomewhat leſs than the Ant of the ſecond ſpecies which I have deſcribed above. The largeſt Ants this gentleman has obſerved he aſſures me were as long as the firſt joint of the thumb; and their neſts were ſix feet long in circumference and were divided into various particular cells: theſe places of reception were ſometimes all found under the earth, and ſometimes moſtly prominent above the ſurface; but they were always framed with an amazing art. I cannot determine how this matter is, for Ants make no neſts here: it is enough for me to give a faithful relation of what I have been informed, and particularly to recommend the authority of this curious gentleman. He likewiſe ſent me the figure of a Frog with that of the red Ant; its hinder legs are cloven, which is very uncommon, and probable the caſe only in Frogs that live on dry land. This will be rendered more certain by accurate reſearches.

The very curious hiſtory of the Naſicornis, or Rhinoceros, or horned Beetle, illuſtrated with accurate figures.

INTRODUCTION.

“WE admire the ſhoulders of Elephants “that carry towers; the necks of “Bulls, and the furious toſſes from their horns; “the ravages of Tigers, and the manes of “Lions: but we ſhould know that nature is “no where more complete and perfect than “in the ſmalleſt objects.” This is a very juſt ſentence pronounced by Pliny in his far diſtant age, though the wonderful works of nature were at that time but obſcurely known. We ſhould therefore, ſurely, endeavour to ſearch into nature near at hand, and where ſhe is conſpicuous in the moſt minute things, or her miracles will never be diſcovered. Then will it be made clearer than the ſun at noon, that as many natural myſteries are hidden in the narrow compaſs of the moſt vile and contemptible of animals, as in the vaſt viſcera of the largeſt. In order to elucidate the incomprehenſible power of nature, it muſt be inveſtigated in the ſmalleſt creatures. Nor let the extreme minuteneſs obſerved in theſe, deter any from the inquiry; it ſhould rather encourage us to be more diligent: for the leſs the work of nature is, the greater and more magnificent it afterwards ſhews itſelf in thoſe at firſt inviſible parts, and exhibits to our ſight and touch all thoſe things which before eluded our ſenſes, and our moſt acute intellectual faculties. The greatneſs and majeſty of God are conſpicuous only in the works framed by his infinite power. But as our eyes are not ſufficiently acute to view theſe things perfectly, it is neceſſary to invent and find out all kinds of aſſiſtances and artificial contrivances proper for aſſiſting the ſight, by the help of which theſe things may be diſtinctly ſeen. By this means, and no other, we can attain to know with what order, meaſure, rule and wiſdom God's creatures are all formed, and how they depreciate all the work of human art and induſtry, the latter not being able to bear too near an inſpection. The beſt of them only expreſs the external ornaments, wherewith the ſurface as it were of God's works are covered; and they are therefore deſtitute of that true food of the mind, wherewith the works of God abound. The more accurately theſe are examined, and the more perfectly they are explained, the more wonderful, lovely, and adorable they always proclaim their Creator. Though many works of art, which derive their powers from nature and the effects of regular motions, perform wonderful things; yet when they are more intimately examined and inveſtigated, they immediately betray the imperfect condition of the artificer. Therefore all the maſterly touches of Apelles, compared to the very refined lines of nature, are only rude, unpoliſhed and coarſe; and all the ſplendor of tapeſtry finiſhed by human art vaniſhes, when only one of nature's works contained in a ſingle pulmonary tube of an inſect is produced: who can delineate even this, the leaſt of theſe wonders, with adequate dignity? what genius is able to deſcribe, or what induſtry can inveſtigate it? our eyes and fingers, and all the powers of our underſtanding are deficient in this reſpect, as will be evident from what I ſhall preſently ſhew concerning the lungs of the Rhinoceros or noſe-horned Beetle; and thus it will be at the ſame time moſt ſtrongly demonſtrated, that the works of God are moſt wonderful in the ſmalleſt objects. Thus I conclude this introduction, crying out with the royal prophet: "I praiſe "thee, becauſe in beholding thy works I am "tranſported with admiration: I celebrate thy "wonderful works when my mind is moſt "enlightened."

Though I ſhall attempt in the following pages to deſcribe to the praiſe and glory of the ſupreme being, the whole change, or, if I may ſo call it, the tranſcretion of the noſe-horned Beetle, conſecrated of old to Mercury, and expoſe to public view its origin, life and propagation; yet I would not have any one think, that I intend to give its accurate and perfect hiſtory. As I happened to be diſſecting one of theſe Beetles in July laſt year, in the preſence of the very learned and experienced phyſician Dr. Matthew Slade, I diſcovered the wonderful conſtruction of its general parts. I was thence led to examine into its origin, and made a diſſection of the Worm out of which it is produced. This having been the occaſion of the hiſtory that I ſhall here exhibit, it will contain no more than an accurate narrative of thoſe things, which I then and afterwards remarked in regard both to the internal and external parts of this inſect. But if God gives me health and leiſure, I ſhall probably at ſome other time proſecute this ſubject much further, though what I now advance is ſufficient to ſatisfy the moſt curious adorers of divine miracles, being of the greateſt importance and moſt wonderful dignity.

CHAP. I.

Of the places wherein theſe Beetles live: of their generation, eggs, Worms and food; how long they are feeding; with varous other uncommon incidents.

As to the places wherein the Rhinoceros or noſe-horned Beetles commonly live, they are moſt uſually our docks and yards, where they lie among the chips and ſaw-duſt, and in the aſhes of reeds which are burned in tarring of ſhips, and among the rubbiſh of kitchen gardens; in the remains of the ſumach wherewith leather has been tanned; as alſo about old trees, and in rotten wood.

Theſe Beetles generate in the months of June and July; the male, Tab. XVII. fig. I. alone has that remarkable horn on his noſe, whence the ſpecies is named noſe-horned; the female is ſomewhat larger, fig. II. the male gets upon the female, and with the horny or bony part of its penis, as with two crooked claws, fixes himſelf upon the horny or bony part, which conſtitutes the vulva of the female; by this means the female cannot eſcape, and the male in this manner injects his ſperm, which it has in great quantity, and ſo impregnates the female. In the ſame manner the male Butterfly of the Silkworms holds its female faſt by the aſſiſtance of two crooked and horny claws, fixing himſelf on the horny or bony ring, in the hinder part of the female's body, and by this means engenders with her, as not being then able to get away from him. The males are ſo very violent on this occaſion, that they will fix themſelves to the females after they are dead; and they are hooked ſo ſtrongly together, that you may tear them to pieces eaſier than ſeparate them.

After coition the female Beetles in this ſpecies penetrate deeper into the wood or other matter; they inhabit and lay their eggs there, not in heaps but ſcatteredly and at diſtances. The annexed figure III. exhibits the magnitude of theſe eggs, though ſome of them *a* are often obſerved to be greater than others *b*, as one female is larger than another. The egg is of an oblong round figure, and of a white colour, and has a thin, tender, membranaceous, flexible and ſoft coat or ſhell; it contracts very eaſily with air, and corrugates or wrinkles up when the moiſture evaporates; the ſame thing happens in Hens eggs when they have not the hard or outer ſhell. It is difficult to ſay in what ſpace of time theſe eggs ought to be hatched by the mere force of the ſun and heat; but about the end of Auguſt we always find the young Worms or Vermicles, fig. IV. which have come from theſe eggs. If one of theſe little eggs be dexterouſly opened with a ſmall pair of ſciſſors, a tenaceous and whitiſh moiſture flows from it. The firſt, and indeed a very rare, change that I obſerved in theſe eggs, exhibited two perſpicuous ruddy points, which were tranſparent through the coat of the egg, and were likewiſe ſurrounded on each ſide; with ſome other ſpots of the ſame kind. I obſerved indeed afterwards, that the two former were the teeth of the Worm yet encloſed in the egg; and that the lateral points were the apertures of the pulmonary pipes. It is extremely worthy of regard how hard the teeth of this Worm are, even in the egg; ſo that this inſect, whoſe teeth attain their perfection before all the other parts, is able as ſoon as it comes to the light to feed itſelf, and by gnawing and devouring the wood wherein it is placed to nouriſh itſelf. The manner in which this Worm is diſpoſed within the ſhell of the egg, likewiſe deſerves great conſideration; it lies there folded up, ſo that its fundament is between its teeth, and the latter reſt on the former. The body being thus folded up, the legs are very curiouſly diſpoſed on each ſide at the verge of the belly, and one may ſee that their claws inſenſibly acquire a colour, and become ſtronger through the coat of the egg. The Worm itſelf, in due time, breaks open the ſhell of its egg in the ſame manner as a chicken, and creeps therefrom to the next piece of wood or other ſubſtance. The Worm *, when thus freſh excluded, fig. IV. is very white; it has ſix legs, and a corrugated or wrinkled body covered on all parts with hair; but its head is then bigger than its whole body, which is a very wonderful thing, and indeed holds likewiſe in other creatures in ſome degree, not excepting even the human ſpecies. As the head of this Worm is horny or bony and extremely hard, the all wiſe-Creator therefore forms it firſt, leſt the other ſofter and more humid parts, which therefore increaſe faſter than the bone, ſhould precede it in growth; and thus has contrived that all the parts ſhould attain their determinate ſize and due form at the ſame time; and therefore the moſt wiſe providence of God here again becomes obvious to our ſenſes. The colour of the head becomes by degrees yellowiſh, and after this ſomewhat red, until it is at length changed into a browniſh red. This Vermicle or Worm has two teeth or jaws, the tops of which are likewiſe cut and divided into ſmaller teeth. Theſe teeth deſerve particular conſideration, becauſe they are ſo large and ſtrong, that one may certainly very properly call them jaws. They may however be much more diſtinctly ſeen in the Vermicle or Worm, whilſt it is ſtill white and lies in its egg, than when it has been for ſome time out of the ſhell and is grown bigger.

If one views theſe eggs from time to time with great care, whilſt the Worm ſtill lies in them, the heart beating on the back preſents itſelf to view. If the ſame eggs be then opened, they exhibit, beſides the outmoſt coat or ſhell, on the inner part, ſome other fibrous and membranaceous little parts, and two very ſingular ones on each ſide, ſituated where the legs are placed, towards which are detached a great many white little fibres. Theſe little parts are like thoſe umbilici or marks at which Peaſe and Beans are fixed to the pods. But this ſimilarity does not hold in reſpect to the office of nutrition, ſince there is no ſuch thing in eggs, for they carry their nouriſhment encloſed within them.

Among all the eggs of inſects, of which I have various ſpecies in my collection, I know none worthy of greater attention than thoſe of Earth-Worms, for theſe inſects have a red blood in their veſſels, which, whilſt the Worm ſtill lies in its egg, may be obſerved to move, and is wonderfully carried about in the heart itſelf. This is the reaſon why I take the preſent occaſion to mention this ſingular phenomenon; though the egg of the Earth-Worm is not larger than that of the Rhinoceros-Beetle, yet the former creeps out of it in form of a Serpent, and is many times as long as it appeared to be in the egg. I ſaw two ſpecies of theſe eggs, of different ſizes, and of an oblong roundiſh figure, uniting on each ſide in a prominent point, and therefore one would be inclined to ſay that this microcoſm or little world had two poles, and that one may hope to diſcover a great many wonders therein. They are of a pale yellow colour, and have a tinge of green. In the ſpring theſe eggs are found diſperſed here and there in the earth. In order to hatch them properly, I put them into a diſh, and covered them with white paper which I always kept wet. If any perſon does this carefully in his chamber every day, he may very eaſily diſcover theſe wonders. In the ſame manner I have alſo hatched the eggs of Snails. I have likewiſe two eggs as big as thoſe of the noſe-horned Beetle, but covered with a perfectly hard ſhell like a Hen's egg, which is indeed very rare.

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* To the Beetle kind we are to look for that deſtructive inſect mentioned in the ſcripture by the name of Kankerworm, and coupled with the Locuſt for its devouring nature. The common mealy Beetle which flies in the evenings about hedges, and which children play with, calling it the Miller Cockchaffer or Dor, is common to the Eaſt as well as Europe, and is probably in its Worm ſtate the creature meant in thoſe paſſages. The Worm hatched from the egg of this Beetle lives under the ſurface of the earth, and feeds upon the roots of corn. A few years ſince it almoſt created a famine in ſome parts of England.

Whoever

Whoever would preſerve theſe and ſuch kind of eggs muſt pierce them with a very fine needle, preſs out the contained humours, and having afterwards blown them up with a ſmall glaſs tube, he muſt fill them with a little roſin diſſolved in oil of ſpike. I have now ſome eggs taken out of the ovary of the human ſpecies and kept in this manner. Theſe I diſcovered in the year 1666, and from hence I began to ſuſpect that I ſhould have found eggs in all other animals; nor was my reaſoning in this point without its foundation.

Let us proceed in the hiſtory of this inſect. As ſoon as the Vermicle or Worm of the noſe-horned Beetle has crept out of its egg, it immediately finds its food ready prepared for it; that is an old tree growing rotten, or the remains of the ſumach, for in thoſe the egg is depoſited by the mother Beetle. Nor does ſhe afterwards take any further care of her egg or of the Vermicle; this creature therefore, though much leſs in bulk, reſembles the tall Oſtrich, whereof the inſpired writer ſays, Job xxxix. 14, 15, 16, 17; “ Which leaveth her “ eggs in the earth, and warmeth them in the “ duſt, and forgetteth that the foot may cruſh “ them, or that the wild beaſts may break “ them. She is hardened againſt her young “ ones, as though they were not hers, her “ labour is in vain without fear: becauſe “ God hath deprived her of wiſdom, neither “ hath he imparted to her underſtanding.” Many are alſo of this diſpoſition, though ſome of them take great pains to depoſit their young among proper nouriſhment. However negligent and careleſs this Rhinoceros-Beetle may be in providing for her iſſue, yet we obſerve in others a much more admirable innate ſenſe or inſtinct, by which they maintain and bring up their young after they are out of the egg. Do not the laborious Ants and careful Bees teach this leſſon? the latter daily nouriſhing their offspring with banquets of the pureſt honey.

Other inſects encloſe their young or eggs in rotten trees, as the celebrated Redi well obſerved. Some again hide their future progeny in the ſhoots of fruits and plants, which for this purpoſe they firſt pierce with ſharp inſtruments, given them by God for that purpoſe: laſtly, others leave or place their iſſue in the bodies of living animals, or in other inacceſſible places, in order to find natural nouriſhment ready as ſoon as they are out of the egg, for it is not allowed them by nature to take any further concern about their progeny.

To this place might be likewiſe properly referred thoſe particular obſervations which I have made on the excreſcences of oaks and other trees and plants. But ſince we ſhall profeſſedly treat of theſe hereafter in their proper place, we ſhall remit the reader thither, and now rather proſecute the hiſtory of the Rhinoceros-Beetle.

How long the Vermicle of this Beetle is in nouriſhing, until it acquires a ſtrength proper for undergoing its change, I cannot eaſily determine: for ſome years before I knew that this ſingular creature was produced from thoſe Worms, I kept them above a year in the remains of ſumach and earth in a glaſs bottle, and during all that time obſerved no change in them. I have likewiſe, not long ſince, kept ſuch a Worm a whole year in the ſame ſumach wherein I found it, without wetting it; however much this moiſture may be requiſite and neceſſary to ſuſtain the life of theſe Worms, this I mention only to ſhew the ſtrength of their life [*]. And hence I alſo conclude, that if this Worm can live for a whole year, after being come to its full growth, ſurely the younger Vermicles or Worms that are not yet grown to perfection, muſt take ſome years to their increaſe, before they attain this ſtate: and it is certainly an admirable thing, that even the Worm out of which the Ephemerus before deſcribed is produced, ſhould require three years before it attains its change, though its appearance under this laſt form does not continue above five hours: this may be ſeen at large in the preceding hiſtory of the Ephemerus.

CHAP. II.

The name of the Worm out of which the Rhinoceros-Beetle is produced; alſo its external parts, diſpoſition and motions. That it loves heat, and that it caſts a ſkin; with other incidents tending to illuſtrate this ſubject.

THE Worm I have been hitherto ſpeaking of, is deſcribed by Mouffet and other authors, under the name of Coſſus, and is, when it is arrived to its full growth, half an inch thick and two inches long, and of a white colour; its body is very deeply wrinkled, Tab. XXVII. fig. v. *a*, and is divided in a beautiful manner into folds or plaits. The whole body is compoſed of annular inciſions common to inſects, and to which authors give the name of annuli or rings; this denomination, however, does not ſeem ſo proper, when theſe annuli or rings are not compoſed of a horny or bony matter, as is the caſe in many beſide theſe. On each ſide of this Worm are ſeen nine reddiſh points or ſpots *b*, not exactly round, but ſomewhat compreſſed like the ſeed of the kidney-bean. Theſe are the orifices of the pulmonary tubes, and hence I call them puncta reſpiratoria, or points of reſpiration. The firſt annular inciſion, which conſtitutes the head, has no point or mark of that kind: the ſecond exhibits the firſt aperture of the pulmonary tubes, over which there is likewiſe a coloured ſpot *c* in each ſide of the body. The third and fourth rings again have no ſuch ſpots or points, becauſe, as ſhall be afterwards explained, the ſheaths or caſes of the wings, and the wings themſelves, which the Beetle to be produced out of this Worm hides under theſe ſheaths, increaſe in proceſs of time in that part, and cannot be perforated. On account of thoſe ſheaths theſe inſects are called vaginipennia, or ſheath-winged. The fifth therefore and ſixth inciſions, and the reſt that follow in order behind theſe, to the number of twelve incluſive, have each their points of reſpiration. The head, which is of a bright red colour, and ſomewhat rough, has ſeveral diſtinct parts, eyes, horns *d*, and teeth *e e*, but the lip is ſplit in two parts, and is viſible among the teeth: above theſe are placed the antennæ or certain prickly and articulated hairs, which lie as it were under the ſkin; theſe are very uſeful when the Worm is feeding. In Locuſts likewiſe the ſame briſtly hairs are obſerved, but more conſpicuous, and they are of great uſe at the time the Locuſt changes its ſkin, and caſts it off from the claws, teeth and eyes. It is not difficult to keep the Locuſts alive, if raiſins are given them to eat; for if theſe are put on a thread one after another, and hung up in a wicker basket, the Locuſts will eat them even to the ſkin. The Coſſus has ſix ſmall legs *g*, three on each ſide of its body, of a yellowiſh red, furniſhed with claws and hair, divided into five joints, and placed at the ſecond, third, and fourth annular inciſions of the body, or the neareſt to the head. The other or hinder rings of the Worms ſhine like a looking-glaſs, the ſkin being there extended and very ſmooth. Hence the ſurface is there of a tranſparent blue, and under it are ſeen ſome of the air-pipes, Tab. XXVII. fig. v. *h*, of a ſilver colour, making a wonderfully elegant and beautiful appearance. The reſt of the ſkin terminated at the anus *i* is covered with fine and tender briſtly hairs *k k k*. The motions of this Worm are ſluggiſh, and all its actions heavy. Its greateſt ſtrength is in the head, breaſt and legs, for by the help of theſe, it immediately forms for itſelf another hole in the earth or other matter, whenever it is taken out of it. And when this happens, it bends its back very much, and gathers its belly as it were into a ſemicircular cavity, nearly in the ſame manner wherein I have delineated it.

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[*] We have an account of the ſtrength of the principle of life in the beetle recorded in the Philoſophical Tranſactions, which is altogether ſurpriſing. Mr. Baker, a perſon of undoubted credit, kept one of theſe alive under a glaſs, without any food, two years and a half, and it then eſcaped by accident. He had firſt attempted to deſtroy it by drowning it in ſpirit of wine, but it revived after repeated trials of this kind, though in one of them it was kept in the ſpirit a whole night.

It frequently happens, that the ſumach or wood wherein theſe Worms live, grows by a natural fermentation warm in the ſame manner as moiſt hay, and at length becomes very hot. The Coſſi do not regard that, for the warmer their habitation is, the better they live in it; they have at theſe times much better health, and are more brisk and lively than uſual, and if they are roughly touched, they are more quick and violent in defending themſelves by biting; though theſe Worms are not otherwiſe of a miſchievous diſpoſition, but on the contrary they are very gentle and mild.

Whilſt the Coſſus becomes inſenſibly bigger, it ſometimes changes its ſkin like the Silk-worm: but I have not yet learned from obſervation how often that happens. Before the Worm caſts its ſkin, it firſt, like Silk-worms, alſo diſcharges itſelf of all its excrements, and then bending its body, it makes a new hole in the earth, that it may be able to caſt its ſkin the more conveniently in a ſeparate habitation. Nothing in all nature is, in my opinion, a more wonderful ſight, than the change of ſkin in theſe and other the like Worms. This matter therefore deſerves the greateſt conſideration, and is worthy to be called a ſpecimen of nature's miracles; for it is not the external ſkin only that theſe Worms caſt, like Serpents, but the throat and a part of the ſtomach, and even the inward ſurface of the great gut, change their ſkin at the ſame time. But this is not the whole of theſe wonders, for at the ſame time ſome hundreds of pulmonary pipes within the body of the Worm, caſt alſo each its dilicate and tender ſkin. Theſe ſeveral ſkins are afterwards collected into eighteen thicker, and as it were compounded ropes, Tab. XXVII. fig. VI. *a a a a a a a a a*, nine on each ſide of the body, which, when the ſkin is caſt, ſlip gently and by degrees from within the body, through the eighteen apertures or orifices of the pulmonary tubes before deſcribed, having their tops or ends directed upwards towards the head. Two other branches alſo of the pulmonary pipes that are ſmaller, and have no points of reſpiration, caſt a ſkin likewiſe, *b b*. Moreover, each of the eighteen points or apertures of reſpiration are likewiſe obſerved to open and dilate their orifices at the ſame time. If any one ſeparates the caſt little ropes or congeries of the pulmonary pipes with a fine needle, he will very diſtinctly ſee the branches and ramifications *c c c c* of theſe ſeveral pipes, and alſo their annular compoſition. The ſkull is then likewiſe divided into three parts 1, 2, 3. Its middle part ſhews the teeth *d d*, which are renewed and the old ones thruſt out: in the middle of theſe is ſeen a lip *e*, and on each ſide there are prominent horns *f f*. Behind the lip may be ſeen the ſkull, terminating like a triangle in an acute point, on each ſide of which are ſeen the two other portions *g g* of the bone divided into three parts. The ſharp-pointed or prickly antennæ are likewiſe changed, and from the eyes themſelves is taken a tranſparent membrane. This happens likewiſe in Serpents when they caſt their ſkin. The exuviæ or caſt ſkin exhibits ſix apertures, wherein the legs *h* were fixed.: and the diviſions or wrinkles, and little depreſſions of the skin are ſtill plainly conſpicuous. Nay, on the hinder part *i*, where the skin is twiſted and complicated, whoever accurately examines the skin itſelf, may ſtill obſerve the coat that was caſt by the inteſtinum rectum. It is likewiſe remarkable, that the skull remains fixed to this caſt skin of the Coſſus; whereas the contrary happens in Silkworms, whoſe skull always ſeparates from the caſt skin, except under the laſt change, when the Silk-worm is changed into an Aurelia or Chryſalis. The head and teeth of the Coſſus, having lately caſt their skin, grow white and become flexible and tender, though they are otherwiſe hard as horn, nay, as bone; inſomuch that when the Worm is provoked, it attempts to bite even iron. But what effect this change of the skin in the pulmonary pipes at length has in the Worm, will afterwards appear, when I ſhall at the ſame time ſhew more clearly, that there are more than eighteen principal branches of pulmonary pipes in the Coſſus, as is likewiſe the caſe in Silkworms. This may be likewiſe exemplified in the Worm of the Hornet, which has twenty points of reſpiration. But I ſhall now proceed to the anatomy of the Coſſus.

CHAP. III.

The anatomy of the Coſſus. The manner in which it is to be killed. Its blood, heart, fat, pulmonary tubes, throat, ſtomach, ſpinal marrow, and the nervus recurrens. Whether the Coſſus is eatable. How it may be ſeaſoned or preſerved, with ſome uncommon obſervations.

I HAVE various contrivances to execute the diſſection of the Coſſus, according to the different ends I propoſed to myſelf in each diſſection; but that which I uſe moſt frequently for this purpoſe, is to kill the Worm in ſpirit of wine, or to ſuffocate it in rain water ſomewhat more than lukewarm: after ſome hours I take it out again, and thus it not only loſes all its motions, but its muſcular fibres are never afterwards contracted, which would otherwiſe very much incommode the diſſection.

When the skin is opened along the back, where the heart is placed, which is extended through the whole back, in form of an oblong canal, and appears about the loweſt rings in the manner of lymphatic veſſels; immediately after the blood, which is a watry humour or ichor, iſſues out at the wound, the moving fibres of the annuli or rings, Tab. XVII. fig. VII. come then in ſight. Theſe are indeed very wonderful to obſerve, and can ſcarce be well deſcribed, for they ſhoot over each other, from one ring to another, in a ſtraight, tranſverſe, oblique or decuſſated direction, and often join one another as by inoſculation. Some of them are longer, ſome thicker, and ſome ſmaller than others, as I have endeavoured to repreſent in ſome degree in the figure juſt now cited. But the muſcles are not ſo beautiful in any of the inſect kind as in Snails, as may be ſeen in their hiſtory, and the figures illuſtrating it.

All along the courſe of the heart in the Coſſus, ſimilar moving fibres are likewiſe placed, which are inſerted into the heart itſelf; and they, like ſo many different little ropes, expand and contract it. The external ſurface of the heart reſembles a membranous oblong tube, fig. VIII. *a*, which is very narrow *b* about the top, and is likewiſe contracted like a knot about the middle of the body, and widens again *c*, and at laſt is joined *d* very cloſely in the hinder part under the thirteenth ring. On each ſide of the heart are ſeen ſome blackiſh uneven points or ſpots, which render the heart, though tranſparent enough of itſelf, the more diſtinctly conſpicuous.

If the inciſion be afterwards made ſomewhat wider, the fat appears, conſiſting of innumerable, very ſmall, and as it were ſandy, fig. IX. globules, which, when viewed with a microſcope, ſeem to be again compoſed of innumerable and yet ſmaller particles, all which are ſupported by very thin and tranſparent membranes or coats, fig. X. *a a*, which are variouſly diſtributed through the body of the Worm, and with their number and diverſity very much obſtruct the ſight of the internal parts. If this fat be viewed with a microſcope, the pulmonary pipes *b b* appear to run up and down through it, and the fat itſelf is exhibited in form of minute, oily, globular particles *c c*, ſwimming between white, ſpherical, and membranaceous parts. But when the fat of the Coſſus is received into a ſmall glaſs, and placed on a burning coal, ſtill covered with its aſhes, then in roaſting there iſſues out of it an oily white ſubſtance in great abundance, which being put on paper has the ſame effect that oil has, and when thrown into the fire it burns very bright; and therefore from all theſe ſigns, I conclude it is of the true nature of fat. This fat is not of a regular but various figure in its diſpoſition, like certain pneumatic veſicles, which I ſhall hereafter delineate in the ſheaths or caſes of the wings. This, however, is to be underſtood only in reſpect to the diviſion of theſe tranſparent coats, whereby, as a foundation, the fat is ſupported, for the figure of the particles of the fat itſelf is commonly ſpherical. In the Silk-worms, whoſe fat is yellow, it appears of a very irregular form. When this fat of the Coſſus is further examined, with the help of a powerful microſcope, it appears of an unſpotted whiteneſs, and is covered or ſurrounded with tranſparent little bubbles, almoſt like bladders: it is contained or encloſed in little membranes, and is a real oil or fluid fat; and hence therefore if theſe membranes be wounded a little with the point of a very fine needle, it eaſily flows out, and a drop of it then falling into water, ſwims on the ſurface like other fat. Whilſt this fluid fat, diſcharged in this manner, and the white membranous particles are breaking, the object in general is thereby darkened, and the water becomes muddy, as if there was ſtarch, lime, or chalk mixed with it; becauſe the fat then divides itſelf into many little particles: but it is more beautiful to ſee this in the Nymph than in the Worm. The fat of larger animals, viewed with a microſcope, is likewiſe obſerved to conſiſt of very minute particles; which, becauſe they are white, one would ſay are like grains of ſand; however, they are not ſo tranſparent, and all of them ſeem to be almoſt of the ſame ſize, which is not the caſe with reſpect to ſand. Therefore the globule compoſed of fat ought not to be conſidered otherwiſe than as a maſs of little grains of ſand faſtened together, though every particle of fat is contained in its diſtinct membrane, all which break in pieces and fall to the bottom, when the fat is melted. In the firſt rudiments of calves and ſheep, in the wombs of their parent, theſe ſmall particles of fat appear even to the naked eye, without a microſcope; for as there are not a great quantity of them there, they may be the more diſtinctly obſerved.

To proceed: as therefore the fat hinders much the view of the internal parts, this impediment is increaſed by the addition of the pulmonary tubes or pipes, for they are diſtributed through the Worm, in eighteen principal branches, in ſo different and beautiful a manner as cannot be expreſſed by words. Theſe branches proceeding from the points of reſpiration, are afterwards divided into innumerable little ſprouts and ſhoots; ſo that there is no part in the Worm, to which ſome of theſe air-pipes or their ramifications are not extended. They are conveyed even to the muſcles, to the brain, to the nerves, whoſe moſt minute diviſions are likewiſe provided with their air-pipes. Wherefore this Worm, as well as the other ſpecies of inſects, ſeem indeed to be ſuſtained much more by the power of a ſubtile air, than the larger animals and thoſe which moſt abound with blood: unleſs one ſhould be inclined to think that the air is mixed with the blood, by means of the circulation, and with this is carried through the arteries to all parts of the body, which opinion is indeed not very improbable. All the pulmonary pipes in the Worm are ſtraight, and have on bladders, for only the perfect Beetle has them.

We ſhall now leave the conſiderations of theſe pipes, and explain more accurately the other parts. The firſt of them that offers in our diſſection is the ſtomach; which is indeed ſeen moſt diſtinctly, when the Worm's ſkin is entirely opened, Tab. XXVII. fig. XI. and XII. *a a a a*. It then appears that almoſt the whole body of the Worm is poſſeſſed by this part. It conſiſts of ſeveral coats, and has moving circular fibres, whereby its contents are agitated. It is always, except when it caſts its ſkin, found diſtended and full of chewed wood, or the like ſubſtances, amongſt which the creature lives; and this is the reaſon that it appears bluiſh, or ſometimes reddiſh, its contents being eaſily ſeen through its coats. This ſtomach is very narrow at its origin, at the mouth, whence it forms the gullet *b*; but it is a little after expanded until it makes its upper orifice called the œſophagus. In that part the ſtomach *c* is on the inſide in front armed with about ſeventy little tooth-like parts *d d*, whereof ſome are longer than others. Theſe are divided into ſix orders, whereof the two upper ones, 1, 2, look forward with their points, but the other four, 3, 4, 5, 6, which are conſpicuous toward the lower parts of the ſtomach, have their ends directed partly to the fore *e* and partly to the hinder *f* parts. All theſe open into the ſtomach, in the ſame manner as the appendages in fiſhes open into the inteſtine next to the ſtomach. But I ſhall not take upon me to affirm that one of theſe tubes is inſerted into another; as is the caſe in the Whiting. I only would ſay, that each tube ſeparately opens in the ſame manner as may be ſeen in the Salmon, in which the pancreas opens into an ecphyſis with above ſixty peculiar and diſtinct tubes. A little lower the ſtomach is rendered conſpicuous by twenty-two whitiſh glandular tubes, Tab. XXVII. fig. XI. XII. *g*, whoſe ends are turned towards the hinder parts. Finally, about the lower part *h* of the ſtomach, a little above the beginning of the pylorus, are likewiſe obſerved thirty ſuch tubes *i i*, which are alſo uneven, and ſome ſhorter than others; theſe are there ſituated obliquely and run inward; theſe alſo open into the ſtomach there, and their ends point forward. If the middle ſeries of the tubes before deſcribed are broken off from, or taken out of, the ſtomach, they reſemble the crown of a trepan. On the other ſide, where the ſtomach lies in the belly of the Worm, and the tubes are directed towards the hinder parts, a ſuture like the ridge of the peritonæum divides it *f*. There are infinite pulmonary fibres alſo inſerted in the ſtomach: on each ſide of the ſtomach are likewiſe placed ſome ſmall veſſels *k k k k*, diſpoſed in a very regular and beautiful manner, which I call the vaſcula varicoſa & crocea, the ſwollen and yellow veſſels, after the example of the celebrated Malpighius, who in his excellent treatiſe on the Silkworms, has given that name to the like veſſels in that inſect. Where the ſtomach terminates about the pylorus, is ſeen a narrow and ſhort inteſtine *l*, which is ſoon dilated *m* into a large, thick, and very capacious, though ſhort, gut, and may be properly called the colon; for it is of the ſame ſtructure with the colon in the human ſpecies. This inteſtine is commonly found very full of excrements, which are like the dung of Dormice. It is by reaſon of the thickneſs of this inteſtine, which is naturally ſo vaſtly diſtended, that the leaſt or loweſt annuli or rings are ſmooth and tranſparent. Another reaſon is, that, as the Worm has no fat about theſe parts, the ſilver-coloured pulmonary pipes, diſtributed all over this inteſtine, appear very beautifully through the tranſparent skin; and indeed the elegance of this ſight is the more remarkable, becauſe the inteſtine is of a purpliſh or bluiſh colour. The pulmonary pipes juſt now mentioned reach on each ſide *n n*, from the points of reſpiration to this inteſtine, and are diſtributed thereon, as well as on the extremity of the ſtomach and ſtraight gut. I have omitted repreſenting here the other pulmonary pipes, that I might be able to exhibit the other eight orifices *o o o o* thereof in their natural ſituation, and as they ſhew themſelves when the fat and all other impediments are removed. This inteſtine bends itſelf by degrees towards the ſtomach, and there ends in a narrower canal, which is directly under it *p*, and which I call the ſtraight gut; becauſe it agrees with that inteſtine in figure, inſertion and uſe.

I at firſt ſuppoſed the ſpinal marrow, Tab. XXVIII. fig. 1. to be in this, as it is in other inſects. But afterwards, by opening two Worms which I had kept ſince the laſt year, I obſerved that the marrow in this creature differed very much, not only from that of other inſects, but alſo from that of the Silkworms, to which in many things elſe the Worm has great reſemblance. As the marrow in the Silkworm conſiſts of many globules, which the celebrated Malpighius has been pleaſed to call ſo many brains, this, being formed in a quite different manner, ſcarce extends to the third or fourth annular diviſion of the body; but whatever part of it afterwards reaches to the other rings of the Worms, or whether what we ſee there are no more than nerves ſhooting from this principal body of the marrow; which, like ſun-beams, beautifully and wonderfully diſtribute themſelves through the body of the creature, and thus give ſenſe and motion to the circumjacent muſcular parts, none yet can ſay. Though there is a diſtribution like this in the Silkworm, yet the ſpinal marrow itſelf in that inſect is extended through the whole body. Hence the marrow in the Coſſus is very ſhort, but the nerves are longer. I have again, ſince the firſt experiments, examined this marrow in a ſmaller Worm, which I had raiſed from the egg; but becauſe the body of the Worm is very ſhort and compact, the marrow is therefore ſituated ſomewhat deeper, and thence appears very diſtinct and beautiful. The *a* brain of the Coſſus is placed in the head, and conſiſts of two hemiſpheres, which together form one body. In the fore part are ſeen four little nerves iſſuing out of the ſubſtance of the brain; alſo, out of each ſide of the brain there iſſue two remarkable nerves *b*, which firſt leave a large opening between them, and afterwards again meet together a little lower, and there conſtitute the body of the marrow *c*. This marrow, it appears, may be divided into fourteen globules, as it were diſtinct, whereof the three laſt together form one more globular diviſion: moreover, the nerves very elegantly branch as they ſpring out of this marrow.

We muſt here obſerve that the gullet paſſes through the opening of the marrow which we have juſt named, in its courſe towards the external mouth of the Worm. And indeed there was a neceſſity for this ſtructure, for as the ſtomach and gullet are ſituated in the neck and belly, and the brain lies above in the head, the marrow muſt neceſſarily have been ſituated only on one ſide, unleſs there had been a hole in it for the gullet to paſs through; hence it is contrived that the marrow poſſeſſes the middle of the body. The moſt wiſe Architect of the univerſe has taken care, by means of this opening, that the marrow ſhould not be forced to twiſt or turn itſelf round about the gullet, which could ſcarce have been any other way avoided. In the ſame manner the gullet paſſes through an opening of the marrow in Silkworms: this the famous Malpighius has neither deſcribed nor delineated. This author has likewiſe delineated fewer globules of marrow than are really in the Silkworm, and he has entirely omitted the brain. But it is eaſy to add to what has been diſcovered before. As this marrow is divided only once, and that at the beginning of its courſe in this Worm, it opens many times in the Silkworms, as Malpighius has very juſt remarked. It is alſo further remarkable that two conſiderable branches of the pulmonary tubes, which are ſilver coloured, and glitter like mother of pearl, are obſerved to paſs over the marrow of the Coſſus in many ſerpentine windings. Theſe branches with their ramifications accompany the nerves iſſuing out of the ſpinal marrow, unto their fineſt or moſt delicate diviſions, which is alſo the caſe in Silkworms. However great, therefore, the difference may be between the marrow of the Coſſus and Silkworm, the brain and branching nerves meet again in both. The nervus recurrens, Tab. XXVIII. fig. 11, deſerves moſt conſideration of any; becauſe, as in larger animals, and in man, this provides nerves for the beginning of the ſtomach, and other parts adjacent: it performs the ſame office equally in the Coſſus and Silkworm. But in order to underſtand how this is managed, I muſt repeat what I have before obſerved, that the gullet paſſes from the external mouth of the creature, through the opening of the marrow towards the ſtomach, and that therefore the marrow ſeems to be divided into two parts, purpoſely that it might tranſmit the gullet. A further advantage that ariſes from this is, that the brain is there lodged gently on the gullet, and is joined to it by means of the emitted nerves and connecting pulmonary pipes ; ſo that the brain lies above on the gullet, and again the gullet and ſtomach are placed upon the ſpinal marrow ; which part having no bone, is thus defended by them. The brain then being ſituated in the manner thus mentioned in the Coſſus and in Silk-worms, emits underneath from its baſis two tender little nerves, which I repreſent, fig. II. *aa*, as they appear when cut out of the Coſſus. Theſe nerves, called recurrentes, are directly from thence carried *bb* upwards towards the mouth, and being then very beautifully bent they run back *cc*, and uniting *d* a little above the brain, form a knot there. Out of this knot there ſprings another nerve *e*, which being conveyed under the brain, and deſcending along the gullet by degrees towards the lower parts, reaches to the beginning of the ſtomach, and there, before it inſerts its branches in the ſtomach, making another knot leſs than the former, at laſt terminates in numerous very ſmall nerves *g*: but theſe I could not trace further in the preſent experiments; though I am confident I could do a great many more things in theſe matters by the help of ſome peculiar methods of diſſection, if I had not been then ſtinted in time.

As theſe nervi recurrentes are extremely remarkable and worthy of conſideration, I have therefore repreſented them ſeparately, and ſomewhat beyond their natural ſize. In the next place I have added a very exact figure, wherein the brain, fig. III. *a*, the ſpinal marrow *bbb*, &c. the nervus recurrens, and the reſt of the branching nerves are ſhewn as they appear in Silk-worms. But there are two of theſe nerves very remarkable *pp*, which I would have the reader ſeriouſly and repeatedly conſider : they are perforated *ss* in a wonderful manner by the vaſſa deferentia of the teſticles in the Silk-worm Butterfly *rr*. But whether this conduces to pleaſure in this ſpecies of inſects, or to any other uſe, I leave others to determine. I have in the ſame manner delineated with the others the genitals of the Silk-worm Butterfly, and expreſſed them in the ſame figure with theſe nerves. A ſhort explanation of this, as well as of all the other figures, will be found at the end of this work.

I have found out an excellent and uncommon method of preſerving all theſe parts of the brain and marrow, by the help of which I can form them into a body, and keep them in their natural colour and ſize ; whereas otherwiſe they are utterly deſtroyed by keeping. I ſhall communicate it when I publiſh my peculiar anatomical obſervations. I have, as a ſpecimen of the uſe of this method, preſerved in this manner a great many ſuch minute parts, which though they cannot be inveſtigated and examined without infinite induſtry and tedious labour, in the creatures themſelves, yet when they are thus preſerved, preſent themſelves more familiarly to view than in their natural bodies.

I cannot in the courſe of this hiſtory avoid relating, how much the Peacocks and Peahens are delighted with eating theſe Worms; and hence I am inclined to believe what Mouffet alledges from Pliny and Hieronymus, that the ancients uſed to eat them as a very delicate kind of food in Pontus and Phrygia. But probably this was the ſpecies of Coſſi, out of which the larger Beetles are produced. If any perſon would eat the Coſſi of our country, they muſt be firſt kept faſting until all their excrements are conſumed. When I have a mind to keep the Worm itſelf for future obſervations, I make a ſmall inciſion in the hinder part of its body, and having afterwards preſſed out the entrails through the wound, I fill the cavity with injected wax. Another method is this : all the fat of the Coſſus muſt be firſt conſumed with oil of turpentine, and then it may be preſerved according to art. This different and much more uncommon method of preſerving, I ſhall likewiſe explain in due time *.

CHAP. IV.

The manner wherein the Worm is changed : how its inward parts are transformed in their increaſe and growth, and the wonderful metamorphoſis of the Worm into a Nymph. Alſo the method whereby the points of reſpiration, or breathing holes, are tranſpoſed : to which are added many uncommon obſervations.

WHEN the time of this Worm's change approaches, which in the year 1673 happened on the ſixteenth of Auguſt, in thoſe I obſerved the Coſſi penetrate deeper into the ground, or into whatſoever ſubſtance they inhabit, and ſeek for places that are more firm or compact, wherein with the preſſure of their hinder part, they form a very artificial oval cavity, Tab. XXVIII. fig. IV. every where ſmooth and poliſhed. They lie a little while immoveable in this cavity; and immediately after they become, by degrees, by voiding the excrements and by the evaporation of their humidity, more ſlender, ſhorter, and uneven in the body, with more furrows or wrinkles than before; theſe, however, are alſo diſpoſed on the ſkin in a very beautiful manner: and hence both the diſtention and clearneſs of the ſkin diſappears ſo perfectly, that one would think the creatures were ſtarved by degrees, and their ſubſtance conſumed with hunger. It is remarkable that at this time the internal parts of theſe Worms do not appear protuberant through the ſkin, as is the caſe in Silkworms, and in the Worms of Bees and other inſects; though one may ſee even theſe already under the skin, and alſo diſtinguiſh by what degrees they increaſe.

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* The Beetles are a genus of inſects ſcarce leſs numerous than the Butterflies. We owe the firſt rational attempt towards arranging them, and diſpoſing them in method, to our countryman Dr. Martin Liſter: he divided them firſt into the land and water kinds : the firſt comprehend all thoſe called by this author Scarabæi ; the latter Hydrocanthari, or water Beetles. Theſe laſt are of two kinds, according to their place of living, ſome delighting in freſh, others in ſalt waters. There are vaſt differences in their horns or antennæ, of which we ſhall ſpeak preſently ; but theſe do not ſo happily diſtinguiſh them as the two great diviſions of the Butterflies.

Before I proſecute this matter further, it is neceſſary to know, that if the Coſſus be diſſected about this time, its diviſion into the head, thorax, and belly, may be diſtinguiſhed very clearly. The gullet, fig. v. *a*, keeps its original form: but the ſtomach *b b* is changed and greatly contracted: the ſame likewiſe happens about its appendages, *c c c*, for theſe almoſt totally vaniſh. The vaſa crocea or varicoſa *d d*, the yellow or knotted veſſels beforementioned become more looſe and free; though in the mean time they do not yet ſeparate from the ſtomach. On the hinder part of the ſtomach, about the pylorus *e*, is ſeen the inſertion of theſe veſſels; for they ariſe there in four diſtinct tubes, ſo that properly they ought to be called inteſtina caeca, cloſe or blind guts. The ſame may be likewiſe ſeen in diſſecting the Bee-worm, in the figures of which I have likewiſe delineated theſe veſſels. The inteſtine colon *f* to this time nearly keeps its bigneſs, nay, it now preſents *g* its little cells to view more diſtinctly than ever. Towards the hinder parts, under this, or towards the inteſtinum rectum *h*, are ſeen curious veſſels twiſted in a wonderful and very beautiful manner, on each ſide of that inteſtine *i i*. We may likewiſe at this time eaſily divide the ſubſtance of the ſtomach into its three coats, and diſtinguiſh its moving fibres.

It is admirable beyond all comprehenſion, how the Worm of the Hornet that is to put on the form of a Nymph, diſcharges at the ſame time all its excrements, together with the inward coat of the inteſtine, or rather of the ſtomach, which embraces or contains them; ſo that by this means this entire membrane and all the collected fœces are thrown out of the body together. The ſame thing happens in this caſe as does with reſpect to infants whilſt encloſed in the mother's womb: for they likewiſe retain together in their inteſtines until the time of birth all the excrements which are formed in the ſpace of nine months. I have alſo obſerved the ſame thing exactly in the Calves from the Cow's belly: nay, what is very ſingular is, I have found in theſe excrements hairs in every reſpect like thoſe that cover the ſurface of the body, and particularly thoſe about their mouth. From this obſervation I really think it is moſt clearly proved that animals often lick their body in the uterus with their tongue, and thus ſwallow their own hairs with their food; and that thoſe hairs are afterwards mixed with excrements as I have found them. Therefore it is moſt ſtrongly demonſtrated, that the humours wherein the animals ſwim in the uterus, and which are likewiſe found in their ſtomachs, ſerve them as food. Their excrements are whitiſh in the upper part of the inteſtines, and yellow a little lower; a little deeper they are of a yellow green and blue; and at length, in the end, they are of a brown and blackiſh colour. The excrements that are found in the Worms of Hornets are in all reſpects of the ſame form, figure, and ſubſtance: hence it is clearly evident, that all the Worms of Hornets feed upon one kind of food, and this is principally a ſmall ſpecies of Cantharides. In theſe Flies the little parts over the eyes, the legs, and the caſes which cover the wings, are obſerved to glitter like gold, and theſe are found in their fœces. The Hornets therefore bring up their young like birds of prey.

After we have obſerved the manner wherein the external and internal parts are changed by a ſlow accretion in the Coſſus, it gives us pleaſure to obſerve that ſuch of its parts as are not to be changed at all, and others which have lately increaſed by degrees under the skin, are gently diſtended by the force of the blood and impelled humours: hence it happens, that the body in general contracting itſelf more and more, and all the blood being propelled towards the fore parts, the skull at length opens very artificially into three parts; which likewiſe happens, as we have before obſerved, in the change of the skin, which the Worm undergoes. The skin then likewiſe opening in the middle of the back, is, by means of an undulating motion, which is obſerved along the annular inciſions of the back and the reſt of the body, carried down inſenſibly by degrees: and hence the eyes and horns, the lip, and the ſharp-pointed antennæ, caſt their exuviæ or skins at one and the ſame time, and are extended, and inflated with blood, humours, and air: they thus acquire by degrees the ſituation which they before had in the Coſſus. Whilſt all theſe things are doing, a watery and thin moiſture is diffuſed between the new and old ſeparating skin, which renders the parting of the two the eaſier.

The firſt part of the Nymph that appears after this change of the skin, is the horn on the noſe, fig. vi. vii. and viii. *a*, which before lay under the skull in the Coſſus ſtate. Under this are afterwards ſeen ſome very low prominences on the baſis of the horn *b*. At each ſide of it alſo two ſpherical tubercles appear *cc*, iſſuing from the teeth of the Coſſus, which are much ſhorter here in the Nymph as alſo in the future Beetle, than they were in the Coſſus or Worm. Near theſe tubercles on each ſide are likewiſe ſeen two other pair of ſphericle ſimilar tubercles *e e*, which ſprung from the horns *f f* of the Coſſus, and which are to be afterwards changed into the horns of the Beetle. Two ſuch little parts alſo, but more oval in their ſhape, are obſerved *g g* to be placed on each of the inward parts of the ſides of the former tubercles. Theſe little parts have their origin from the jointed *h h* briſtly hairs of the Coſſus; and are likewiſe, though in another form, found afterwards in the Beetle. Three beautiful ſhort tubercles preſent themſelves alſo in the middle *i*, which upon changing the ſkin have likewiſe ariſen from thoſe particles, which may be ſeen in the head of the Worm under the letter *k*. A little under theſe there appears alſo a larger ſphericle diviſion *l*, which is horny or bony in the future Beetle, and forms the neck which is beſet on each ſide with hairs. Above this, near the horn, is ſeen on each ſide the breaſt bone *m*. A little lower on the breaſt is ſeen the firſt pair of legs 1, 1, with their joints: and under theſe another pair 2, 2. Then follow the *n n* ſheaths or caſes of the wings on each ſide, under which a part of the covered wings *o o* is likewiſe prominent. Theſe wings appear at this time beautifully expanded by the force of the blood and air that are by degrees impelled inwardly, though they were before complicated, and appeared as if grown together under the ſkin of the Coſſus. Below theſe is placed the laſt pair of legs 3, 3, which are in ſome meaſure covered with the wings and their caſes. All theſe legs and their joints are ſtretched out ſtiff, and diſtended with the fluids of the body and air, and thus remain without any motion fixed in the ſame poſture, until the Nymph is changed into a Beetle. Finally, under the laſt pair of legs may be ſeen the rings of the abdomen *p p*, diveſted of their ſkin; and the extremity of the fundament *q*, out of which the inteſtinum rectum has caſt its exuvia or ſkin, as the gullet did with the upper parts. Theſe little parts are like two ſmall ſhields. As to the eyes they are very conſpicuous in the Nymph, but they cannot be repreſented by the ſame figure, becauſe they are ſituated a little deeper behind the horns. The whole motion of the external parts of the Worm is now totally loſt, in the ſame manner as it was before when the Worm was in its egg: hence the creature is twice as it were in a uterus, and twice in the ſtate of a fœtus. Some ſmall motion remains in the tail or fundament of the Nymph, becauſe the extremity of the abdomen undergoes the leaſt change of all. Thus the Nymph, by moving the hinder rings of its body or tail, can move itſelf and change its ſituation in its little cell: this is likewiſe performed by the Chryſalis of the Silk-worm when it lies in its web.

In this moſt wonderful change of the ſkin, and tranſpoſition of limbs and parts of this inſect, nothing demands greater attention, than what we may obſerve about the points of reſpiration: for though each of thoſe nine points which are ſituated on each ſide of the body caſts a ſkin, yet this can be diſtinctly affirmed only of the five foremoſt ones, for the four loweſt or laſt points on each ſide change their ſkin as the reſt, but they loſe all their priſtine form at the ſame time; three of them on each ſide become ſhorter, and the fourth is entirely cloſed up. At the very ſame time that the Worm, under this prodigious change of its ſkin, is transformed into a Nymph, a vaſt number of diſtinct tubules or pipes is likewiſe thrown out from all thoſe reſpiratory points, and theſe tubes, being each obliged to paſs through that narrow orifice, appear like ſo many ſmall and ſimple filaments, though, in reality, each of theſe eighteen little fibres, as they ſeem, is compoſed of many pulmonary pipes, that are laid cloſe together.

In order to underſtand theſe things the better, I ſhall add a figure to the deſcription of them, and in Tab. XXVIII. fig. IX. a Nymph of the Coſſus laid on its belly, and ſhall exhibit all the annular diviſions and points of reſpiration in its back. Theſe points ſhall be afterwards ſeverally repreſented in their ſituation, as they appear after the Nymph is changed into a Beetle. The firſt thing then ſeen here is the horn of the noſe 1, fixed on the head, which conſtitutes as it were the firſt ring of the creature: then follows the ſecond annular inciſion 2, wherein the firſt point of reſpiration is placed, ſo ſituated laterally under the firſt pair of legs in the breaſt, that it does not appear but when the Nymph is killed. The third and fourth rings, 3, 4, are ſeen both without points of reſpiration, becauſe the wings and caſes thereof are placed there *. Beſides theſe, two annular inciſions in the Nymph are concreted into one ring, and then form the lower part of the thorax or back. In the mean time, when theſe parts are caſting their ſkin, on each ſide between the rings of the thorax, two little ropes as it were of pulmonary tubes are caſt out of the body, as has been before repreſented in the figure, where we have deſcribed the change of the ſkin which the Worm itſelf undergoes. But theſe apertures are afterwards cloſed up in the Nymph, until having caſt its ſkin, it at length becomes a perfect Beetle, wherein theſe orifices are at length totally aboliſhed. The fifth ring 5, contains the ſecond point of reſpiration, which cannot be ſeen diſtinctly, being ſituated partly under the wings of the Nymph. But a particular, very worthy of notice here, is, that this other point of reſpiration is in the Nymph removed to a greater diſtance from the firſt, than it had been at firſt in the Coſſus itſelf, and as I have figured it in that ſtate; ſo that by this means it is conſiderably drawn back towards the hinder parts. The ſixth ring 6, next to the former, contains the third point of reſpiration, which is very diſtinctly ſeen externally in the Nymph, at the extremity of the abdomen. In like manner the ſeventh ring 7, ſhews the fourth point of reſpiration, and the eighth 8, ſhews the fifth. But the ſixth and ſeventh points of reſpiration, conſpicuous in the ninth and tenth 9, 10, rings are again cloſer. The eleventh, twelfth and thirteenth rings 11, 12, 13, conſtitute as it were one connected joint together; and the eighth and ninth points of reſpiration, which are ſituated at or near theſe rings in the Worm, likewiſe become not only cloſer and more compact, but the laſt of them is in this ſtate almoſt inviſible. As to the fourteenth ring 14, it is not viſible when the Nymph is in this manner placed on its belly, but on the other ſide it is ſeen beautifully, reſembling two oblong oval little ſhields. O wonderful changes! whereby the creature comes into the world as it were new formed, and yet is moſt certainly the ſame that it was in the Worm.

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* In the outer caſes of the wings in Beetles there is a vaſt diſtinction, not only in colouring and ornament, but in ſhape; ſome cover the whole body, and are a defence to the inner wings, with little foldings of thoſe more delicate parts: but in others theſe outer wings or caſes of wings are ſhort, and only fall over the ſhoulders. This is the caſe in that common and diſtaſteful black Beetle which crawls about damp hedges, with its body naked and annular; the under wings are beautifully folded up under their ſmall caſes.

The Worm being in this manner diſengaged from its skin, transformed by accretion, and having its limbs and parts changed into the ſtate of a Nymph, cloſely twiſts and compreſſes the caſt skin by the motion of its fundament, and the ſkin is afterwards thrown towards the hinder parts under the belly. The Nymph is at that time very white, only that on the fifth, ſixth, eighth, ninth and tenth rings of the back, there appear ſome delicate or horny hardiſh corpuſcles, which approach to a bright red colour; in the little ſhields alſo of the laſt ring, and here and there in its body and legs the like ſubſtances are at this time alſo ſeen. The Worm or rather the Nymph is at this time very delicate, tender and flexible, and as it becomes remarkably ſhorter, on the other hand it is expanded conſiderably in breadth and thickneſs; for the blood and air have very conſpicuouſly inflated the wings and the reſt of the parts, in the part towards the head, and diſtended them ſo that they are become rigid. If we view this Nymph nearer, we obſerve that the tranſparent productions of the windpipe appear not only in the legs, but in the wings themſelves, and in their ſheaths and caſes; nay, they are ſeen alſo in the ſubſtance of the horny or bony part that ſtrengthens the thorax.

About this time the Worm or Nymph reſembles a tender young infant very lately brought into the world, and which is rolled up in its firſt ſwaddling cloaths, and cannot yet bear much handling. We may more properly indeed compare this Nymph to an Embryo, which, being lately conceived in the uterus, may, by force of the injuries offered it by the mother's imagination, be injured in various manners: for the impreſſions which the Nymph receives at this tender age, are not aboliſhed even when it is grown up or is become a Beetle. Hence, if the horn, legs, or other parts are bent in the Nymph, or diſturbed in any manner, they always afterwards remain thus deformed in the Beetle; and the Beetle carries with it through life the veſtiges or remains of all the injuries inflicted on this feeble and tender little creature; this is agreeable to the ſentiment of the poet:

Quo ſemel eſt imbuta recens, ſervabit odorem
 teſta diu. ——

That is,
" A new veſſel will long preſerve the ſcent of the firſt liquor poured into it."

This change therefore merits the greateſt admiration and the moſt attentive regard, by means of which the creature for ſome days exhibits the future parts of the Beetle ſo finely and beautifully diſpoſed, and formed in ſuch a manner, as that they will one day ſerve the creature in a more perfect ſtate of life, to walk, fly, and take its nouriſhment. I therefore really think, that the Coſſus of this ſpecies comſtituted in the form of a Nymph, affords an appearance ſo ſingular, that among all the ſtrange and aſtoniſhing appearances of inſects, it cannot be equalled. I ſhould be very glad to ſee hereafter the Nymph of the ſtag-horned Beetle, for I ſhould think it would make a much more ſplendid figure when it prepares itſelf like a bride, in all its decorations, for a new and more noble ſtate of life.

The Chryſalis of the ſwift Butterfly deſcribed by J. Banhinus in the year 1590, among the Mouches ou Papillons non vulgaires, or the uncommon Flies or Butterflies, is very rare and admirable. Aldrovandus, Lib. II. Cap. de Chryſ. Tab. VII. fig. 1. exhibits a kind of figure thereof. Mouffet alſo, pag. 105, deſcribes the leaſt ſpecies of the ſaid Butterflies, and properly calls it the ſwifteſt of all, for indeed the ſwallows do not fly with greater velocity than theſe little creatures.

One thing very ſingular in theſe Butterflies is, that they fly and eat at the ſame time, though this alſo is the caſe with ſwallows, and among inſects with the Libella or Dragon-Fly. On the other hand ſome Flies, after they have ſeized on their prey, reſt in ſome convenient place to devour it, as in particular the Wolf-Fly. But as Swallows eat and fly at the ſame time, ſo theſe, at other times nimble Butterflies, flutter when they feed in ſo ſlow, regular, and orderly a manner about the flowers where the food proper for them is depoſited, that you would imagine they had loſt all motion, and hung ſuſpended in the air; but they are hard at work all the time, for they then thruſt out a very ſlender proboſcis or trunk about two inches long, with two perforations in it, through which they ſuck the honey of the flower; and this being exhauſted, they ſo quickly draw back this ſurpriſing organ, and ſo artfully coil it up between the little forked parts which are placed under their eyes, that it entirely diſappears, ſo that to find it out, one muſt be well accuſtomed to the ſtudy of theſe creatures. This inſect being ſcarce, I have given the figures of it, as it appears in the reſpective ſtages of its exiſtence as Worm, Tab. XXIX. fig. I. Chryſalis, fig. II. and Butterfly, fig. III.

As the manner of feeding of this Butterfly is very ſingular, I ſhall add another obſervation of the ſame kind, in regard to the manner of feeding of a certain aquatic inſect that always lives under water. This inſect is, properly ſpeaking, no other than a peculiar kind of water Worm, conſiſting of thirteen rings, the head and tail included. The head is very large in proportion to the creature's ſize. It has ſix hairy legs, fig. IV. *a a*, beſides two ſpots or ſmall parts covered with hair likewiſe *b*, which terminate the tail, and are uſed by the creature when it ſwims as a rudder to govern its motions. The inſect by means of this tail, can alſo at pleaſure ſuſpend itſelf on or near the ſurface of the water; when it erects its tail above the ſurface, the water flows from it on every ſide, and thus is this ſuſpenſion formed. This inſect has beſides in its head two very remarkable teeth, or more properly jaws *c c*, which are large, ſharp, crooked, and very ſtrong, and it is perhaps able to contain the muſcles ſuch teeth or jaws require, that nature has made the head ſo large. This Worm has ſix eyes *d d* on each ſide of the head. I have here repreſented eight of them. There are beſides ſix articulated briſtles belonging to it, of which four *ee ee* lie underneath and between the teeth, and the two others under the head *f f*; but ſome may imagine that theſe laſt ſhould be called horns.

This is a cruſtaceous creature like a Shrimp. On each ſide of the body are ſix holes for reſpiration *g* in the rings of the abdomen, with two more for the ſame purpoſe under the body near the fore legs. This Worm is repreſented in the moſt curious figures of Hoefnagel, that were engraved after his minute and moſt accurate deſigns, part firſt, page I. Mouffet alſo deſcribes it in the 37th chapter of his theatre of inſects, and gives in ſome ſort a drawing of it. This inſect lives entirely on other little creatures that inhabit the ſame element, in particular on the Scrophula and ſmall freſh water ſhell fiſh. When about to eat, he ſeizes with the two teeth we have mentioned the little creatures that come in his way, and pierces their body with its ſharp and crooked points, which being perforated from the point to the root, he in a ſurpriſing manner ſucks through them into his mouth the blood of the unfortunate captive. This may be eaſily ſeen, eſpecially when the blood of his prey is of a red colour, as the teeth are tranſparent. I threw to this Worm a bit of a Coſſus, at the ſame time carefully obſerving with a microſcope how he devoured it: together with the blood, there aſcended ſome air in ſmall bubbles through the cavities in his teeth. The ſight of this creature in the water is very acute, for which purpoſe nature has ſupplied it, as I already mentioned, with twelve black eyes, which are placed at ſome diſtance from one another, but theſe eyes, like the eyes of other inſects, have no motion, and therefore are placed in a different manner from thoſe of Crabs, Crawfiſh and Shrimps, which are moveable. When therefore this Worm perceives any thing that it likes, it immediately darts at the object through the water, ſeizes it, and pierces it with its ſharp pointed teeth. In this manner we may procure ourſelves a very entertaining and ſurpriſing ſight, by throwing to it a ſmall Earthworm; for let this laſt move, twine, and otherwiſe beſtir itſelf ever ſo much, the other keeps his hold, and very calmly ſucks the blood of his priſoner. The inteſtines of this Worm differ extremely from thoſe of land inſects; its windpipe has fewer ramifications, though theſe at the ſame are more large and ſpacious. They are likewiſe more membranaceous, of a leſs firm texture, and not of quite ſo deep a colour. The heart is ſituated near the back, and the ſpinal marrow in the lower part of the body. This laſt conſiſts of globules as in the Silkworm, but theſe lie ſo cloſe to each other that they form a connected body of marrow, more like that of the Coſſus than a Silkworm. In the part where the nerves unite with theſe globules, the ſpinal marrow itſelf looks like a bracelet compoſed of coral beads ſtrung upon two threads. The remaining parts are the ſtomach and the inteſtines, which are partly of a white and partly of a bluiſh gray colour, the ſame with their contents, from which indeed they receive it. The Vaſa Crocea, or yellow veſſels, as they are uſually called from their colour, are in this inſect purple, or otherwiſe, they are thick ſet with purple ſpots, but they look whitiſh at bottom, which affords a very agreeable ſight.

On examining with a microſcope the teeth of this Worm, they appear very ſharp pointed, Tab. XXIX. fig. V. *a*, and a little bent towards the point. There was likewiſe a kind of ſuture *b* in that part where I cut out one of them, formed by a ſharp protuberance in the middle of the upper ſegment, with a ſuitable cavity in the middle of the lower to receive it, the edges about both being ſmooth and even *c*. The aperture by which this inſect ſucks the blood of its prey, lies on the ſurface of the tooth near the point *d*, and reſembles an oblong ſlit, with black edges covered with very fine hairs. It is extremely probable that ſome peculiar ſpecies of the Water Beetle proceeds from this Worm, when having remained in the water a ſufficient time, it betakes itſelf to the land to undergo its mutation; but this is mere conjecture. The horſe Fly has another method of feeding itſelf, being furniſhed, as I have elſewhere remarked, with a ſting as well as a trunk or proboſcis. As to the Gad Fly and its Worm, I ſhall hereafter treat of it by itſelf, under the fourth order or claſs to which it belongs; but I cannot help remarking in this place, that the Worm from which it comes breathes by its anus, and carries its legs in its mouth near the jaws; thus ſerving to prove that the Almighty can form veſſels of every kind like the potter, ſome for more, and others for leſs honourable purpoſes, but all to his own glory; ſo that there is not a creature, however contemptible in appearance, which does not clearly point out the exiſtence, and loudly ſing forth and extol the adorable perfections of a ſupreme Being.

C H A P. V.

In what manner the Nymph is filled with a ſuperfluous moiſture, which afterwards evaporates. The anatomy of the Nymph. How, on caſting off its ſkin, it becomes a Beetle, with ſome wonderful diſcoveries in natural hiſtory.

HAVING ſhewn in the foregoing chapter what the Nymph is, and by what means the Worm puts on this elegant form, to prepare itſelf as a bride for its enſuing nuptials, and for the act of generation; I ſhall now treat of thoſe changes, by means of which the Nymph attains this preſent ſtate, and at the ſame time give a diſſection of ſome of its internal parts; for thus the reader will more eaſily underſtand how this Nymph grows at laſt to a Beetle, and being arrived, as ſuch, to a ſtate of maturity and perfection, propagates its ſpecies.

The firſt thing to be conſidered on this occaſion, is that peculiar motion of the blood and humours, which expand the parts of the Nymph, and make it weigh at firſt, a little after its change, a great deal more than it does even afterwards in the Beetle ſtate. This ſingularity is likewiſe remarkable in the Nymphs of Bees and Hornets. The Nymph of the Hornet in particular weighs ten times as much as the Hornet itſelf. This makes me conſider the Nymph under theſe circumſtances as a dropſical perſon, who, by having his limbs ſwelled with ſuperabundant humours, loſes the power of thoſe muſcles by which they were to be put in motion, and thus remains inactive till the ſuperfluous moiſture is ſome way or another diſſipated. Nor is it the limbs alone that are thus ſwelled in the Nymph; all the muſcles themſelves partake of the change, and even the very bone into which they are inſerted. This, which was before of a horny ſubſtance, loſes its ſolidity, and by becoming membranaceous and ſoft, and in a manner fluid like water, is no longer capable of being acted upon by them, and continues in this condition, till the ſuperfluous humours are evaporated in a certain ſpace of time, which is abſolutely neceſſary for that purpoſe. We may perceive by a continued obſervation, that the external ſkin of the Nymph is at firſt extremely delicate, that it hardens, as it dries, by degrees, and that its colour grows more and more yellow, till it changes at length to a deep red, after that to a deep brown, and at laſt to a light red. But all theſe appearances are owing to the growth of the internal parts, in order to form the future Beetles, as they ſhew themſelves through a tranſparent ſkin that covers them.

When this Nymph has paſſed ſome days in ſweating off the ſuperfluous moiſture, with which it is loaded, a little articulated whitiſh line appears like a ſlender thread through the tranſparent ſkin, with which the legs are covered, which is no other than the firſt rudiment of that horny or bony ſubſtance, which begins to harden, and is in time to conſtitute the legs of the creature. On ſtripping off this ſkin, and attentively examining the ſolid or horny part it contains, the latter appears to float in a limpid fluid, which ſurrounds it on every ſide, and is at this time ſo very tender that it is eaſily injured, and will fall off on the ſlighteſt motion. But what ſeems chiefly to claim our wonder is, that the Worm which grows from the noſe of the male Beetle of this ſpecies, ſhould be ſo very hard at its perfect growth, as, according to Mouffet, page 153, to bear being ſharpened on a grinding-ſtone; whereas the ſame organ, while the inſect is in a Nymph ſtate, is altogether ſoft, and more like a fluid than a ſolid ſubſtance.

On diſſecting ſome of theſe Nymphs after they had been in that ſtate a little time, I found the horn of the noſe filled with a kind of jelly, and this matter broke out at the wound made to examine it, every time the creature breathed, in the ſame manner as the blood of a man's body does when the ſide of the thorax is wounded. The eyes were now ſomewhat firmer, but nevertheleſs they were ſtill loaded with ſuperfluous humours. I found between the folds of the wings and the caſes that covered them, ſome inſects of the Louſe kind, which I have likewiſe often obſerved ſticking to the body of the Coſſus and to the Beetle itſelf; for there is perhaps no ſpecies of animals which is not troubled with this kind of vermin, though thoſe of one animal differ in ſhape from thoſe of another. Such part of the wings as had no caſe to cover them, had, to make up for that deficiency, a much thicker ſkin to defend them, than the parts which were thus ſheathed. On pulling the legs from the thorax, the skin came off from thoſe of the future Beetle in the form of a ſtiff ſheath, juſt as a boot comes off a man's leg. It is alſo very remarkable, that the extremities of the pulmonary tubes were inſerted into this external skin of the inſect. But I ſhall hereafter ſpeak of this matter more at large. The inteſtines which lay in the abdomen were formed in quite a different manner from thoſe of the Worm, of which I have before given a figure, and in particular they had more ſinus's. The ſtomach itſelf ended in a kind of very ſmall gut, and indeed all theſe alterations ſeemed requiſite to prepare the parts to the great change in the body itſelf, which was grown at this time conſiderably ſhorter than before. But as the ſtomach was greatly abridged, and therefore its muſcular parts had without doubt ſuffered conſiderable changes, both that and the inteſtines were now ſoftened into a kind of ſlimy humour to facilitate ſo ſurpriſing a change. The pulmonary veſſels retained their former ſituation and figure. The whole abdomen was filled with a kind of calcarious ſubſtance reſembling ſtarch, and of ſo bright a white as to dazzle the eyes of all who ſaw it. On a nearer examination of this ſubſtance, I found it to be nothing more than a collection of thoſe little bags in which the fat is depoſited, and which little by little loſe their form and office, and are at laſt ſo entirely waſted away, together with their contents, that not the leaſt veſtige of either is to be found in the ſucceeding Beetle. About this time ſome ſpots are obſervable in this moſt extraordinary ſubſtance, of a brighter white than the reſt of it, and many of the pulmonary tubes ſeem to take their direction towards theſe particular parts. This induces me to think they may be the rudiments of the pneumatic bladders with which the Beetle is furniſhed in a vaſt abundance, unleſs we are rather to conſider ſuch pneumatic bladders as conſiſting of the pulmonary tubes dilated occaſionally to anſwer that purpoſe. For my own part I cannot take upon me to decide this point. I obſerved the ſame things in the Nymphs of Bees, after I had finiſhed the hiſtory of thoſe inſects: but be this as it will, theſe ſpots are ſo brittle and tender in the Nymph that they are deſtroyed by the ſlighteſt touch: by their dazzling whiteneſs alſo they hinder us from diſtinguiſhing properly the adjacent parts: for this reaſon, to proceed well in our examination, we muſt be conſtantly waſhing with fair water the inteſtines of the inſect. Were it not for this obſtacle, we might doubtleſs here diſtinguiſh many more things worth of notice. In the thorax, ſome parts were a little more ſolid. The muſcular fibres of the legs and wings were ſomewhat more firm or tough than the white of an egg juſt beginning to harden. All the other parts were as ſoft and tender as poſſible. On ſeparating the external skin of the body from the internal, the ſpace between them was found to contain a great quantity of moiſture, but in many places this ſeparation was abſolutely impoſſible.

As the ſeveral parts in the Nymph grow by degrees ſtronger and ſtronger, the inſect may be ſeen to make a proportionable uſe of them. We ſee the legs move within the skin that covers them, and even the claws that terminate the legs begin to brandiſh themſelves up and down. The ſame is viſible, and in the ſame manner, in the Aureliæ of Silkworms during the laſt days before their tranſmutation: if during this period you ſtrip the legs of their external skin, you will find very little moiſture under it. Even the horny or bony ſubſtance which conſtitutes the joints of the legs appears hard, perfectly formed, and covered with hair.

I cannot ſay how long the ſcene of this inſect's mutation continues, having forgot to take notice of it, though at the ſame time I was witneſs to the change of above fifty of theſe Nymphs into Beetles. Sometimes theſe inſects remain in a Nymph ſtate during the whole winter, eſpecially when the Worms throw off their skins towards autumn, and a ſudden cold ſucceeding checks their further operations. Hence it happens that they remain without food for ſome months, nor could they take it to any purpoſe, their parts being too ſoft and tender to allow them to make uſe of it.

When the proper ſeaſon of the Nymph's final change approaches, all its muſcular parts are obſerved to grow ſtronger and ſtronger, to be the better able to ſhake off their laſt integuments, and this is performed in the ſame manner exactly as in the already deſcribed change of the Worm to a Nymph; ſo that in this laſt ſkin, which is very delicate, the traces of the pulmonary tubes that have been pulled off and turned out become again viſible; nor is their number limited to eighteen, there appear abſolutely twenty of them, as has been already ſufficiently obſerved.

It is now proper to ſee how all the parts of the inſect, but eſpecially the wings and their caſes, are at this time ſwelled and extended by a flow of air, blood and humours, driven into them through the arteries and pulmonary tubes. About this time the wings are as ſoft and flexible as a piece of wet paper, ſo that blood iſſues from them at the leaſt wound. But when they have acquired their due hardneſs, which in the ſheath or caſes is very conſiderable, the veſſels that before yielded blood ſo freely, are ſo firmly cloſed, that neither they nor the wings can by any cutting or tearing be brought to yield the leaſt fluid. This induces me to advance as a thing not to be doubted, that whereas theſe wings and their caſes are ſo full of veſſels and pulmonary tubes, they ought to be conſidered as conſiſting entirely of ſuch veſſels and tubes. It is alſo probable, for the ſame reaſon, that the membranes and skin of the other creatures are no more than a complication of veſſels, as nerves, arteries, veins, lymphatic ducts and the like, for ſo long as the embryo's of the human ſpecies and of quadrupedes remain in the womb, their skin appears compoſed of nothing elſe. The ſame may be ſaid even of the bones themſelves;

and

and this obſervation alone would be ſufficient to recommend to our attention the hiſtory of the inſect now under conſideration. It would take too much compaſs in this place to deſcribe the ſurpriſing alterations which happen in the membranaceous wings of butterflies, and how evidently nature manifeſts herſelf, and exhibits her wonderful powers in theſe minute creatures: certainly the great and wiſe ſovereign of the univerſe made every thing for our uſe, and to his own glory. All his creatures, the leaſt as well as the greateſt, furniſh us with proofs of his gracious intentions, his ſtupendous majeſty, and the immenſity of his power.

We therefore, on obſerving the mutations and tranſpoſitions of the growing parts of man and other animals, may well cry out with the royal prophet: “ My ſubſtance was not “ hid from thee, when I was made in ſecret “ and curiouſly wrought in the loweſt parts “ of the earth. Thine eyes did ſee my ſub- “ ſtance, yet being unperfect; and in thy “ book all my members were written, which “ in continuance were faſhioned, when as yet “ there was none of them. How precious “ alſo are thy thoughts unto me, O God! “ how great is the ſum of them!”

Hence we may juſtly declare, that inſects, even under this miſerable ſtate of mortal life, acquire as it were a heavenly exiſtence; for thoſe which in the former part of their life inhabited the earth, lived in mud, and under thorns and briers, and fed on coarſe proviſions, in their more perfect ſtate, raiſe themſelves into the purer air, and flying towards the skies, maintain themſelves with honey and oozing liquors of flowers: ſome of them can even abſtain from food during many months. Are not all theſe conditions much better than thoſe to which they were ſubject under the troubles and anxieties of a former more vile earthly life? but I ſhall illuſtrate theſe ſubjects more fully, when I have leiſure, in order thence to demonſtrate the glorious reſurrection of the dead, by the moſt evident and palpable proofs drawn from nature; for I can produce ſuch manifeſt examples and ſuch powerful arguments for the purification and ſucceeding glorification of bodies, from the hiſtory of inſects, that I do not doubt but ſuch unheard-of miracles will ſtrike all mankind with the higheſt amazement. Natural truths are perfectly convincing and wholly divine; ſince what is true proceeds from God, who is truth itſelf. And what is more true, than that the books of nature are thoſe viſible things, by the aſſiſtance of which, as by ſacred ſteps, we aſcend by various advances, to divine and eternal truths? for it is God himſelf who is the author of Nature.

CHAP. VI.

The difference between the male and female Rhinoceros Beetle, after the Nymph caſts its ſkin, and is changed into either of them. Of the points of reſpiration, the eyes, the brain, the optic nerves, the pulmonary tubes and pneumatick bladders. Of the heart, and of the genital organs of the male and female, with a moral concluſion.

THE Nymph of this curious Beetle being diſengaged from its skin, in the manner explained in the preceeding chapter, aſſumes a quite different form, in which it is dignified with the name of the Beetle, whoſe internal parts, with the difference between the male and female, I am now about to deſcribe. Before I begin this explanation, I muſt obſerve that the Nymphs, which have their horn prominent in the fore part, always become male Beetles in this ſpecies; but ſuch as have no horn always females: and there are very certain external ſigns for diſtinguiſhing the ſex of theſe inſects. Beſides, the males, which have ſmaller bodies than the females, have alſo two larger and more beautiful horns *, whoſe tops have knobs thereon made like combs; and, when the creature is flying, they are expanded in the manner of the leaves of an open book: this is a very wonderful ſight in ſome of the Beetle kind. But as ſome remarkable things occur, which are common to both male and female, I ſhall firſt deſcribe them, and afterwards proceed to the peculiar points which mark the difference of ſex.

The parts common to both are, firſt, the points of reſpiration ſituated outwardly; ſecondly, the eyes and the brain; thirdly, the pulmonary tubes and pneumatic bladders; and laſtly, the heart. The things peculiar to each are the horn and genital parts in the male, and the ovary in the female. I ſhall proceed to deſcribe theſe in order and with brevity: as to the particular deſcription of the other external and internal parts, the diſpoſition and manners, the uſe they make of their wings, and their food, and the length and ſhortneſs of their lives, as alſo how far they are hurtful, and how far innocent, with other like reſearches; theſe I ſhall at preſent paſs untouched, partly becauſe I have not yet ſufficiently ſearched into them, and partly that I am fatigued beyond my ſtrength, with inveſtigating, delineating, and deſcribing thoſe amazing things. I muſt have a long ſpace of time to perfect all theſe inquiries; nor can any perſon execute ſuch things perfectly, but he who can ſpend his whole life upon them.

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* The antennæ of Beetles are of two kinds; thoſe which are pointed at the end, and thoſe which have that part ſhaped in the manner of a comb.

There is alſo a difference of a very particular kind in their inſertion, the greater part have them fixed upon the ſubſtance of the head; but in ſome they are carried upon a kind of trunk: the Beetles which have them in this ſtrange ſituation, are thoſe the antients called Gurguliones.

Upon theſe forms and inſertions of the antennæ may be eſtabliſhed an exact claſſical diſtribution of them, a thing yet wanted in natural hiſtory.

Of thoſe things, which are outwardly conſpicuous in this Beetle, the points of reſpiration deſerve our greateſt attention; theſe I ſhall now deſcribe and repreſent by a figure, as they are naturally diſpoſed on one ſide of the perfect inſect; for they have the ſame ſituation and ſtructure alſo as the other. They vary conſiderably from thoſe which are ſeen in the Worm, for here they are diſpoſed in a different order near each other, and are placed in a ſomewhat oblique and declining ſituation; by this means one of them occupies an higher place in the body than another; they are likewiſe more oval, not round, and are much deeper, or more hollow than before, and appear as it were like little trenches and furrows in the Beetle much more than in the Coſſus: the cavities alſo of the canals which they diſtribute internally in the body, are much wider and more open than they are obſerved in the Worm; for as the Worms live in duſt and under the earth, and creep up and down there, it was neceſſary that their pulmonary tubes ſhould have orifices more cloſe and even, leſt the duſt ſhould ſlip into them.

The firſt of theſe points is placed inwardly, Tab. XXIX. fig. VI. *a*, in the cavity of the ſecond ring of the body, or in the os pectoris, or breaſt bone; nor is it viſible there till after that bony ſubſtance has been ſeparated from the body. The ſecond *b* is ſomewhat further diſtant from the firſt, and being turned more toward the lower parts, is directed thence obliquely towards the other. This point, which is conſpicuous immediately under the wings, is placed on the ſide of the fifth ring of the body. The third *c* again is ſituated ſomewhat higher, along the courſe of the curvature of the abdomen, and this lying upon the ſixth ring of the body, is not far diſtant from the ſecond. The fourth *d* again is placed ſomewhat lower and nearer the former, and is ſituated upon the ſeventh ring of the body. The fifth *e* ſtands ſomewhat lower and is placed on the eighth ring. Theſe five points of reſpiration, whereof the Beetle has as many on the other ſide, and which makes ten in all, are indeed the principal places through which it draws its breath; for the other eight, which were viſible in the Coſſus, are in this perfect ſtate of the creature partly preſſed together, and ſome totally cloſed up; becauſe the body is become ſo much ſhorter than it was in the Worm. All theſe five points are covered in each ſide of the body with the caſes or ſheaths of the wings, except when the creature is flying; for at that time the ſheaths of the wings are lifted up, and remain elevated without motion; hence theſe points are likewiſe at that time diſcovered: and this ſeems continued that the Beetle might the more freely draw its breath on this occaſion, fill its pneumatic bladders with air, and thus make itſelf lighter for flying.

Moreover on the ninth ring of the body there is obſerved a ſixth point *f*, on the tenth, a ſeventh *g*; and on the eleventh, an eighth *h*; all which are very conſiderably contracted and depreſſed, and run along each ſide of the body. But as the abdomen terminates by converging into a ſort of a point, and the twelfth, thirteenth, and fourteenth rings are wonderfully contracted and diminiſhed in their diameter, hence the ninth point *i* of reſpiration is totally obliterated in each ſide of the body, as I have before with ſufficient clearneſs deſcribed and figured in the Nymph. But I now only repreſent the natural ſituation of theſe points.

The eyes are alſo extremely remarkable in the perfect Beetle, and they differ very much from thoſe in the Worm, as well in bigneſs and number as in figure. Each ſide of the head has one, which conſiſts of a congeries of many ſmaller globules or little eyes, forming by their union as it were one common net or reticulated body. This is properly made of the tunica cornea, for the eyes of all the inſects that I know, have the exterior tunica or coat conſtructed or formed of a horny or bony matter, and divided like a honey comb into hexagonal parts, all which are on the upper part ſpherical or projected like little globes. But theſe globular diviſions are not in this Beetle ſo remarkably protuberant as in Flies and Bees; they are much ſmoother, more depreſſed, and ſmaller, and they have no hairs. Theſe horny diviſions penetrate from the outmoſt ſurface to the inmoſt, and ſeem to be formed within by a kind of net of hexagonal pulmonary tubes running through each other. Within this net the uvea tunica, or a part analagous to it, is ſeen on the inſide under the cornea. This is of a blackiſh colour, and is regularly received into the inward cavity or hollows we have named in the cornea, ſo that by this means it is to be found only in the uppermoſt ſurface, and not in the bottom of the eye. In the eyes of men and quadrupedes the uvea ſinks to the bottom, and is alſo perforated in the anterior part; but neither of theſe is the caſe in the eye of the Beetle, and for this reaſon no rays of light can be collected in this caſe inwardly in the eye; but they only paſs through the ſpherical diviſions of the cornea, and are then immediately ſtopped upon the uvea. I would not preſume to affirm that the rays are by any means collected, when they paſs through the cornea, though this is not improbable. If one removes the uvea, by means of water and a fine pencil, from out of the inward cavity of the cornea; this latter becomes then all bright and clearly tranſparent.

After the uvea follows a matter or ſubſtance like glue; it is ſomewhat viſcid, but thin, and divides itſelf into very fine filaments, Tab. XXIX. fig. VII. *a*: theſe may be taken for inverted pyramidal fibres. When the cornea tunica is removed from theſe filaments, blackiſh ſpots are ſeen on the eye, which are the remains of the uvea ſtill ſticking there; for the pyramidal fibres are by means of the uvea connected with or joined to the ſpherical apertures of the cornea. All theſe fibres terminate in a thick, fibrous, and inexpreſſibly white tunic or coat, Tab. XXIX. fig. VII. *b*; the ſubſtance of this, however, is of a darker colour *d*, where it is united to the optic nerve which is here ſeparated *c*. Many pulmonary tubes likewiſe run up and down here, which ſtrongly connect that coat with the optic nerve, which it receives: theſe air-pipes paſs alſo through that white fibrous coat we have deſcribed, and are conveyed *e* along the inverted pyramidal fibres, reaching to the cornea itſelf in form of very delicate ramifications; and in my opinion form the hexagonal diviſions of the eye. Here at length may be conceived, in what manner the eye, whilſt the exuvia or skin is caſting, acquires its extenſion, form, and roundneſs by the help of the internally impelled air and blood. The roots of theſe pulmonary tubes are found to be ſituated under the optic nerve, where they firſt provide for the coat, wherewith that delicate nerve is inveſted; and thus, with a conſiderable ramification adhering underneath, is alſo ſurrounded with or accompanied by ſuch air-tubes.

But we muſt here take particular notice that theſe eyes are, in each ſide of the head, divided as it were into two parts, fig. VIII. *ff*, as I have repreſented in a particular figure, wherein is likewiſe exhibited *g* the horn of the head. This diviſion is produced by means of two horny or bony prominences of the skull, which extend themſelves from each ſide of the eye unto the outmoſt ſurface thereof; hence it happens that the eye is in the ſame manner divided in its internal part, fig. VII. *h*; ſince the inward ſtructure is analagous to the outward. The optic nerve has no inciſion or diviſion, but the pyramidal fibres are wanting where this inciſion is, becauſe they evidently could be of no uſe there.

In order to diſcover theſe things accurately it is firſt neceſſary to lay the brain bare; for this purpoſe nothing more is requiſite than to cut off the horn, if it be a male, with a ſharp knife, and then to raiſe and ſeparate the cranium or skull from the brain. After this, the brain *i* comes in view. This, as I have before obſerved, when I treated of the ſpinal marrow, conſiſts of two globes united, and is by this means divided into a right and left part, as is likewiſe the caſe in men and in quadrupedes. It is indeed very remarkable that the brain is in this Beetle furniſhed with many pulmonary tubes, Tab. XXIX. fig. VII. *k*, which make a very beautiful appearance in the living animal. Optic nerves are obſerved to iſſue out of it on each ſide, which are much larger in the Beetle than they were before in the Worm. Moreover, a common kind of membrane is obſerved there, which inveſts both theſe nerves and the brain itſelf, and is ſufficiently thick and ſtrong: this may be properly called the dura mater. Numerous air-pipes run through this membrane, and interweave it as it were with one another, ſo that you would ſay this dura matter, when ſeparated from the brain, is like an admirably beautiful net. The optic nerves are very ſlender where they iſſue from the brain *ll*; but they are conſiderably dilated *mm* a little after, and then again they grow ſmall *nn*, until at length they are ſwollen again where they approach to the inward compages or reticulations of the eye *o*. In that part theſe nerves are encloſed and ſurrounded by the interior parts of the eye, and when greatly magnified reſemble the head of a Dutch ſailor covered with a ſhaggy cap, ſuch as ſea-faring perſons uſe to wear: I compare to theſe ſhaggy hairs, thoſe pyramidal fibres which terminate in the convexity of the white fibrous coat.

It may not be improper to obſerve here that this Beetle is very ſhort ſighted, or poreblind. I therefore would have the reader conſider the conſtruction and difference of the Bee's eye, which ſees more acutely in the day time; for he will find that the optic nerve in the Bee does not come ſo very near to the eye, nor is in itſelf ſo remarkable and conſpicuous as in this Beetle. Others may reaſon from theſe facts as they think beſt; it is ſufficient for me to have propoſed the truth. I have not yet examined the eyes of the water Beetles, which I know can ſee both in water and air. I have ſeen the pyramidal fibres of the eyes in Crabs and Lobſters. All water Snails, as well as the human ſpecies, have three humours in their eyes, as I have deſcribed before at large. On this occaſion it may alſo be obſerved that their eyes are ſometimes multiplied. I proceed now to the pulmonary tubes, which are ſimple in the Worm, but are enlarged by the addition of bladders in the Beetle ſtate.

Theſe pulmonary tubes which in the Worm reſembled the branches of trees without leaves, repreſent here in the Beetle a tree expanding its verdant and leafy branches: and here the autumn and winter of the miſerable life which this Worm leads, is now in the perfect Beetle ſtate changed into a pleaſant and lovely ſpring and ſummer; with this only difference, that as the leaves of the trees have a plain and ſmooth ſurface, ſo theſe bladder in the Beetle are hollow, ſomewhat ſwollen, and expanded to an elliptical figure, and are ſomewhat ſwelled or blown up, Tab. XXIX. fig. IX. *a a*, by force of the air impelled into them. There is likewiſe this conſiderable difference, that out of the ends of theſe veſicles, where they reſt upon their hollow pulmonary tubes, other pipes and ramifications *b b* again break out laterally, which, after they have been again dilated into veſicles, form air branches, veſicles and pipes: ſo that this diviſion and proceſs continues, until at length they terminate in very delicate, and as it were inviſible pulmonary paſſages, which always remain round with open cavities. Hence the ſtructure that occurs here may not be improperly compared to the third ſpecies of the Sea Wrack of Dodonæus. Nay, it is likewiſe obſerved that many tubes of this kind ſometimes iſſue *c c* out of the ſame veſicle, which I have repreſented magnified above its natural bigneſs. Whenever the air gets out of theſe veſicles or bladders, they fall and become flat, and by the mutual contact of their ſides, form a plain ſubſtance like the ſmooth leaf of a tree; whilſt in the mean time the tubes affixed to them always remain open. The reaſon of this is, becauſe theſe little branches riſing from the principal air veſſels conſiſt of contorted and ſpiral parts, which, like the rings, made of ſilver thread or wire, and twiſted round a ſmall cylinder, always preſerve their roundneſs. In the ſame manner this ſilvery web of pulmonary tubes appear to me to be compounded of a horny or bony pellucid matter, white as mother of pearl, and wound into ſpirals. Theſe tubes are likewiſe lined on their inſide with very delicate membranes, which keep their ſpiral form with all its windings in their ſituation. But where they are dilated into pneumatic veſſels, they are entirely membranaceous, and beſides, when viewed with a powerful microſcope, are obſerved to be planted or ſet there with ſmall ſtuds or boſſes like little grains. This is indeed a very agreeable object. Moreover, theſe veſicles are of a paliſh or white colour, and having no poliſh are nearly of the aſpect of a Spider-web, or any thing of a like kind, covered with duſt. The tubes on the other hand, are bright and ſplendid, and of a ſilver or of a pearly colour. See the explanation of theſe in Tab. XXIX. fig. x.

The reaſon of this difference between the pulmonary tubes of this creature, while it is in the Worm, and when it arrives at the Beetle ſtate, ſeems to lie in the repeated change of their ſkin, whereof I have made mention before. The ſame thing is in ſome meaſure obſerved in the pulmonary pipes of the Silkworm Butterfly, for in this the tubes of the lungs, becauſe they many times caſt theſe internal ſkins, are every where very much dilated; though they have no diſtinct veſicles. However the matter be, ſince theſe white little parts, which are ſeen in the fat of the Nymph, ought to come principally into conſideration here, I think this difficulty may be at length ſolved, if there were ſome more diſſections made for that purpoſe. But I muſt reſerve the doing of this to another time, and ſhall, till then, leave this matter uncertain. One may conveniently inflate or blow up the pulmonary tubes of the Beetle before deſcribed with a flexible leaden pipe, or the quill of the wing of ſome ſmall bird: what in Holland we call the Cheeſe-bird has feathers admirably ſuited for this purpoſe; for the quills of this bird's wings are very perfectly hollowed throughout, eſpecially if they be firſt ſtrengthened by a ſmall glaſs tube; and theſe parts thus diſtended afford a very beautiful ſight.

Any one may ſee the pneumatic veſſels, together with their tubes, without any diſſection, provided he removes or takes the external wings, called the caſes of the wings, from the body, and views them when turned to the light with a microſcope. They even appear through the abdomen of the Beetle, and they may be likewiſe ſeen in the horny or bony and membranous part which covers the lower part of the body: but they are preſented in the moſt beautiful manner between the plates of the external wings; for there they form innumerable and moſt ſingular figures. Three conſiderable branches of the wind-pipe commonly appear between theſe caſes, that is, two on each ſide, and a third ſhorter in the middle; and out of theſe one may afterwards ſee the reſpiratory veſicles beautifully iſſuing and placed between them, in the ſame manner as I exhibit them here in a minute portion of that part; wherein two larger branches of the trachea, Tab. XXX. fig. I. *a a*, are repreſented on each ſide, and between them the pulmonary pipes iſſuing therefrom, together with their veſicles *b b b b*, out of which other pulmonary pipes ariſe, which are again dilated into veſicles *c c c c*; and theſe are again attenuated into pulmonary pipes, until at length they end in moſt minute and inviſible filaments. In the inner part of the outer wings there may be alſo obſerved ſome other ſmall points, projecting beyond the ſurface of the caſe or ſheath, out of the middle of which iſſue oblong diſperſed hairs. Theſe I am confident are placed here to prevent the ſubjacent wing from being too much preſſed, and at the ſame time to give it the means to fold and hide itſelf the more eaſily under the ſheath. We have before ſhewn the uſe of theſe numerous tubes and pulmonary bladders; which is, that by their help the outer wings or caſes of the wings may be expanded. I would likewiſe have it obſerved, that all theſe veſicles or bladders appear ſomewhat ſmooth, which may probably be owing to the contraction of the ſheath or caſes, which happens when the humours are exhaled, and the blood-veſſels are cloſed or ſhut up.

The heart is much ſhorter in the Rhinoceros Beetle which I am deſcribing, than it was in the Worm or Coſſus; it is likewiſe more knotty; it is in ſome places dilated, fig. VII. *a a*, and elſewhere is again contracted *b b*, as I have ſhewn in a ſmall part of it: but I have not had opportunity to ſearch into it fully. I ſhall therefore now paſs to thoſe parts peculiar to the male and thoſe to the female; ſuch as the horn, the penis, teſticles, and ſeminal veſſels in the male; and the ovary, uterus, and vulva in the female; and after theſe are explained I ſhall conclude this hiſtory.

The parts peculiar to the male.

THE horns of the male Rhinoceros Beetle is formed of a tolerably ſolid horny bone, which makes it ſo firm, that one may bore or pierce even hard wood with it. It is crooked and bent backwards towards the bone of the thorax. It is of a black red colour, and ſo ſmooth and poliſhed on the ſurface that it ſhines like a looking-glaſs: and ſo likewiſe do the covering of the thorax; and the caſes or ſheaths of the wings, called alſo the outer wings: theſe are likewiſe parti-coloured, but approach more to red. The horn is ornamented with ſeveral ſmall holes impreſſed thereon. It is firſt membranaceous in the Nymph, and as it were full of a fluid; it afterwards becomes more firm, and at length acquires the full hardneſs we have named. And though this horn is flexible at the time of the creature's caſting its skin, yet in the ſpace of two or three days after this change, it becomes ſo wonderfully hard, that it is not only as firm as a cartilage, but even approaches to the nature of a bone. It is not, diſtinctly ſpeaking, ſituated on the noſe of the creature, but on the head, and may therefore be moſt properly called a production of the cranium or skull only, for it ſprings out of the ſubſtance of the skull where it lies over the brain. The male only has ſuch an horn by way of ornament. It is on the inſide hollow, as that of an Ox appears when ſeparated from the head, but its cavity is filled with no other matter than the dilated air-bladders; which, together with a multitude of tubes that adhere to them, are encloſed in it, and inſinuate themſelves even into its bony ſubſtance; hence the horn becomes much lighter, ſo that it may be carried the eaſier by the Beetle when it walks or flies. This inſect is therefore properly an Unicorn, for he has only one horn. It will not be improper to mention here, that if a Stag be gelt while young, his horns will never grow. This I have been informed by a curious and creditable gentleman. Wherefore theſe animals become in this reſpect like the female of this our Beetle, when their maſculine vigour is taken away.

With regard to the penis of this Beetle we are firſt to obſerve the nervous and the horny or bony part, Tab. XXX. fig. VIII. and IX. *a*; this laſt is as it were the prepuce, or rather a kind of ſheath for the penis: it is erected principally by its aſſiſtance, and is again drawn back into it when the occaſion is over. On the foremoſt ſide of this caſe are ſituated two little horny bones reſembling claws or hoofs *b*, which, forming a chink or crevice in the middle between them, are capable of being ſeparated from each other by the help of proper muſcles, in order to make a way, or afford a paſſage for the penis when it is erected. The muſcles for this ſervice are ſituated in the bony ſubſtance of the beforementioned ſheath, and are likewiſe articulated therewith. By the help of theſe two little bony claws the male in the time of coition fixes himſelf in the horny part of the female's vulva. Behind this ſheath is placed a nervous, ſoft, and very thick part of the penis *c*; wherein is placed ſuch a horny little bone as I have obſerved alſo in the root of the Bee's penis. Next follows the body or root of the penis *d*, which is nothing more than a ſmall tube, but it has a conſiderable nerve in the place where the vaſa deferentia and ſeminal veſicles meet. I have obſerved this nerve alſo in the water Beetle, and very conſpicuouſly in Bees. The vaſa deferentia *e e* are next ſeen on each ſide, and they contain a very white ſpermatic humour: they are indeed ſomewhat ſlender where they are connected with the root of the penis; but they become again dilated towards the middle, and thence become more ſlender where the principal teſticular veſſel is united with them on each ſide. The teſticles which diſcharge their ſperm through theſe vaſa deferentia, are of a very ſingular ſtructure in this Beetle. They conſiſt on each ſide of a ſimple vas teſticulare, which is about two feet two inches long. On one ſide I exhibit here entirely rolled out and unfolded *f*, whereby it appears at the ſame time, that the end of it is ſomewhat thicker, and, like the cloſe gut or inteſtinum cæcum, has no orifice, Tab. XXX. fig. VIII. and IX. *g*. But on the other ſide I exhibit this teſticle *h* in its natural condition; ſo that only the extreme end of this vas teſticulare appears removed from the maſs *i*. The vaſa deferentia and vas teſticulare have in this creature innumerable pipes and pulmonary veſicles: and by the aſſiſtance of theſe, the convolutions of the teſticular veſſels are firmly kept tied together; ſo that they cannot be diſengaged from each other, unleſs theſe pulmonary tubes are firſt removed, which cannot be done without continued labour and great patience. Between the vaſa deferentia are ſeen the ſeminal veſſels *k k*, which contain a ſpermatic matter of a duskier colour than that of the teſticles or dilated vaſa deferentia. And this ſeminal matter is doubtleſs generated and ſecreted in the veſicles themſelves, as is likewiſe the caſe in the human ſpecies and quadrupedes; in ſome of which the veſicles may be found diſtended with ſeveral ounces of ſperm. Each of theſe veſicles is terminated by a ſmall curled filament *l l*, which is indeed divided on each ſide into ſix ſmall tubes; on the tops of which are depoſited ſo many very beautiful little glands *m m*. Theſe being united to theſe twelve tubes, by their means ſend the ſeminal matter at the time of coition through the veſicles to the penis. I exhibit ſome of theſe glands alſo as they appear *n* when they are more ſwollen in the middle than in the circumference, and are there filled with a pellucid matter, reſembling that ſubſtance in a Hen's egg, which Harvey calls the colliquaneantum. But the ſubſtance which ſurrounds the middle part, is filled with matter like the white of an egg when beginning to concrete. Hence it is eaſy to conclude, that the dusky fluid which is found in the veſicles is generated therein, unleſs one ſhould rather incline to think that it is thus changed in the veſicles, which ſhould have been firſt proved. The middle part of theſe glandules is like a globe cut ſomewhat ſmooth on the top; but if the glandule be inverted *o*, this part appears entirely globular below, and the little branch of the veſſel united to the veſicles is there fixed in its center. This I exhibit ſomewhat larger than the natural ſize *p*, repreſenting in the ſame figure the ſubſtance *q* that ſurrounds it, which contains a ſeminal matter much reſembling the white of an egg. All round theſe glandules and ſeminal veſicles are inſerted numerous branches of the aſpera arteria: one would almoſt think that one ſaw the ciliary ducts in the human eye. The veſicles have no communication with the vaſa deferentia, which is likewiſe the caſe in Bulls and many other animals, and even in other inſects, and as particularly in Bees. All theſe genital parts are perfectly white, except the veſicles, which appear gray on account of the dusky ſeminal matter they are ſwollen with, which is in ſome meaſure ſeen through them. Theſe little parts are ſituated in the lower region of the belly, and are there found folded or wrapped one with another, in ſuch a manner that at the beginning of the diſſection one would think they could not be diſengaged by any induſtry. But patience overcomes all ſuch difficulties. I obſerve further, that inſects differ very much with reſpect to their genital parts, as is plain in the organs of Bees, the water Beetle, and others which I have occaſionally delineated. Theſe parts are likewiſe very beautiful in the Hornet, though I have not yet ſufficiently examined into their ſtructure. I ſhall now paſs to the ovary of the female.

The genital parts of the female Rhinoceros-Beetle.

THE female, which is diſtinguiſhed in this ſpecies by having no horn, Tab. XXX. fig. x. *a*, on its head, ſhews on diſſection, its ovary ſituated in the loweſt region of the abdomen; but it is found to be ſituated higher when it is diſtended with eggs. In order to exhibit this the more clearly, I repreſent it, together with the head and gullet, and the ſtomach *b*, which is very ſlender, and the inteſtines *c*, together with the orifice *d* of the latter, which opens below and near the orifice of the ovary, as they are all naturally fixed among one another. The ovary *e e* conſiſts of twelve oviducts, ſix whereof are ſituated on each ſide, but theſe afterwards meet in certain common paſſages, which immediately afterwards form one ſingle trunk, which may be called the uterus or rather the vagina of the creature. This trunk reaches to the extremity of the abdomen, out of which the female diſcharges her eggs through the horny ring, which is formed like a creſcent, and is ſhaggy *f* in the lower part. In one of theſe common ducts is here exhibited a perfect egg, and above are ſeen four other rudiments or imperfect eggs, adhering in three particular oviducts: the other three oviducts of this ſide are empty or without eggs. On the other ſide may be ſeen three more perfect eggs in the oviducts, which otherwiſe appear very cloſely contracted in thoſe parts, where I have delineated no eggs in them. I diſſected this female the 17th of Auguſt, at which time theſe Beetles have done laying eggs, and even the young Worms are by that time found. But if the extremity of the vagina which is ſhaggy, be examined in the inner part, eight horny and bright red little parts, together with the paſſages that then lead both to the vagina and to the inteſtinum rectum or ſtraight gut, are obviouſly ſeen. Under the vagina, not far from its external aperture, is ſeen an oblong or pear-ſhaped bag, Tab. XXX. fig. x. *g*, which opens by a ſmall tube into the vagina. When this bag is cut, a yellowiſh matter is always found therein, which, after it is concreted, runs into ſmall crumbles, if touched ever ſo lightly: its yellow colour is ſeen through the bag. What uſe this ſubſtance is of I am yet ignorant. Above this bag are found two other tubes, which have cloſe extremities, and unite in one ſhort and narrow tube, which is likewiſe inſerted in the vagina. One of theſe little parts *h* in the Beetle I diſſected was pellucid, like a lymphatic veſſel, but the other was very white *i*, nervous and hard. The uſe of theſe little parts likewiſe is altogether unknown to me. One may alſo ſee here, in what manner all theſe parts are furniſhed with numerous pulmonary tubes, out of which iſſue many pneumatic veſicles or bladders, which likewiſe emit other tubes *k k*, &c. Theſe pipes connect the oviducts, ſtomach, inteſtines, and all the reſt of the parts here delineated firmly together, ſo that they cannot be diſengaged but by repeated efforts. There is a kind a kind of entire trunk *l* of theſe pulmonary pipes, ſeen near one ſide of the common duct of the ovary; and other ſmaller branches *m* are ſeen about the ſtomach and inteſtines. Whilſt I was engaged in drawing theſe pulmonary tubes, I purpoſely omitted to delineate the knotty veſſels or vaſa varicoſa, which are much narrower and cloſer in the Beetle than in the Worm, for I could ſcarce have avoided confuſion, if I had undertaken to exhibit to the life ſo many different minute little parts. It is alſo remarkable both in the male and female, that theſe little inſects are now filled as much with pulmonary tubes as their Worms were before with bladders of fat.

Before I conclude this account, I ſhall exhibit, becauſe it is pertinent to the ſubject in hand, five different exotic Rhinoceros Beetles, each of a peculiar ſtructure. The firſt has a breaſt-bone, fig. II. *a*, which extends into an oblong tube, ſomewhat crooked about the anterior part, and at length ſplit or divided in the extremity. The horn of its noſe has alſo a ſharp riſing from the middle of it. In the ſecond, Tab. XXX. fig. III. *a*, the breaſt is divided into two acute points, in the manner of a fork; and the horn, which like a proboſcis, projects from the ſkull, turns itſelf in a peculiar manner, and is elegantly bent back between the teeth of the fork. This Beetle was brought from Japan. The breaſt-bone of the third, fig. IV. *b*, terminates in a ſhort horn ſomewhat divided; from each ſide of which two other ſhorter crooked points project out of, or from the breaſt-bone: the horn on the noſe in this is likewiſe very ſhort, and terminates in two arched and ſharp-pointed branches. This Beetle was brought from Braſil. I only exhibit the thorax or breaſt-bone of the fourth, fig. V. *c*, becauſe it is in the body like the firſt, ſecond, and fifth. This bone is pretty large at its origin, but it terminates in two ſhort, crooked, obtuſe points, and is adorned alſo on the lower part with ſome ridges projecting beyond the ſurface. The horn on the noſe in this ſpecies is ſplit as in the firſt ſpecies; The breaſt-bone of the fifth, fig. VI. *d*, is divided in various manners, it firſt emits a ſomewhat prominent obtuſe point, afterwards it grows ſmall, and then expands again into an eminence ſomewhat divided, and at length it terminates in two acute points or ends near the eye, one of which is conſiderably larger than the other. The margins or extremities of this bone have two ornaments like thoſe which I mentioned in the fourth ſpecies. The other ſide of the breaſt-bone is divided and extended in like manner as that which I have here figured. The horn that riſes from the noſe is bent back like a ſegment of a circle againſt the prominence of the breaſt-bone [*], and is obtuſe at its extremity. A more accurate explanation of the parts of theſe ſeveral ſpecies will be given at the end of the work.

Now that I am near concluding this ſubject, I ſhall beg my readers to conſider, whether the parts of theſe little creatures changed in ſo wonderful a manner, and formed with an art not inferior to the conſtruction of the human body itſelf, can be formed by the aſſiſtance of heat and moiſture, or be produced by chance from putrefaction? Or whether the infinite wiſdom of God, and that moſt powerful hand, whoſe fingers made the heavens, and framed all nature, muſt be conſidered as the only inſtrument of their exiſtence? I ſhould indeed believe no one would preſume to deny this. I ſhall therefore conclude this hiſtory, by obſerving that the Beetle is only a Nymph diſengaged from its ſkin, and changed by accretion; as the the Nymph likewiſe is only a Worm that has changed its ſkin, and is altered or transformed in the ſame manner: hence theſe ſeveral ſtates exhibit only one inſect under three different appearances, which, after its miſeries and mortifications, is advanced by degrees to a glorious and happy reſurrection. The Worm leads a miſerable life under the earth. The Nymph, deprived of motion, remains long as it were dead; but the Beetle, living at pleaſure above and under ground, as alſo in the air, enjoys a ſuperior degree of dignity, which however it has attained by afflictions and death, for without paſſing through theſe difficulties, it could never have come to that perfection. Here calm and ſerene weather ſucceeds a ſtorm, and death opens the gates to life. Hence the apoſtle ſpeaks moſt juſtly in reſpect to us: "I think "that the ſufferings of our temporary ſtate "are not worthy the future glory which ſhall "be revealed in us." We therefore, treading in the foot-ſteps of our Lord Jeſus Chriſt, and having ſuffered all the miſeries and puniſhments of this life, expect the reward. My ſpirit, in the mean time, raiſing itſelf with fervent zeal to God, cries out: "My ſoul magnifies the "Lord, becauſe he diſcloſes great things unto "me: he is powerful, and his name is holy.

The end of the wonderful hiſtory of the RHINOCEROS-BEETLE.

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[*] We have in England two ſpecies of Beetles which are able to leap in a very ſurpriſing manner. In other inſects this motion is performed by means of the legs, which are made of various lengths and forms adapted to that purpoſe: but theſe creatures do it by means of their thorax, which is alſo formed in the under part in a peculiar manner riſing and elaſtick for that purpoſe: one of theſe is of a cheſnut brown, the other of a greeniſh black. They both have flatted bodies and ſlender legs.

CHAP.

A particular treatiſe on the Culex or Gnat, which likewiſe belongs to the firſt method of the third order of natural changes called the Nymph.

AS Ants, Bees, and Beetles are generated from a viſible egg, in ſuch a manner that an intermediate Worm firſt iſſues out of this egg; in the ſame manner a Worm or Vermicle, out of which the Gnat has its origin, is produced from the egg of a winged parent. As the ſeveral parts of the Worms out of which the juſt mentioned three inſects ariſe and increaſe by degrees under the ſkin, and the creature having caſt it, at length appear to our ſight, all theſe incidents have place in the Worm and Nymph of the Gnat. But there is, notwithſtanding, in this inſect a conſiderable difference, which is, that whilſt the Nymph of the Ant, Bee or Beetle, is without motion, and cannot change its place, this Nymph of the Gnat, on the contrary, has the power of loco-motion, and ſwims in the water; for this reaſon, it appears at firſt ſight to approach in a great degree to the Nymphs of the ſecond order.

On a juſt examination of the ſubject, this difficulty will be found, however, of ſmall moment: for the Nymph of the Gnat, in reality, has no more motion in its legs than the other Nymphs of this third order; for it is never obſerved that it moves in the leaſt its head, breaſt, horns, wings or legs; the contrary whereof is obſerved in Nymphs of the ſecond order. For this reaſon, though the Nymph of the Gnat has ſo ſtrong a power of moving from place to place, yet that is no obſtacle to prevent our referring it properly and juſtly to the third, and not to the ſecond order.

The true reaſon of the difference conſiſts in this, the change which the tail of the Nymph of the Gnat undergoes, is not ſo remarkable, as that the Nymph ſhould thereby loſe the faculty of moving briskly. The tail is the only part, by the help whereof this Nymph changes place. The limbs and other parts in this Nymph, are in reality as immoveable as they are in the Nymphs of Ants, Bees and Beetles. And even theſe Nymphs are not wholly deprived of the power of moving their tail, as is evident in the Nymph of the Rhinoceros-Beetle juſt deſcribed; for this can, by the motion of its tail turn itſelf a little in its terreſtrial habitation. But in the Nymphs of Ants and Bees this is not obſerved, until they have paſſed the greater part of the Nymph ſtate, and are very near changing their ſkin. Having therefore removed this difficulty, which might appear more conſiderable than it is to thoſe leſs acquainted with theſe changes. I ſhall proceed to give the particular hiſtory of the Gnat and its Nymph; from the particulars of which all thoſe things which have been ſaid in the preface will be better explained and eaſier underſtood.

The Gnat is produced out of a very ſmall egg, which is expoſed or caſt into the water by the parent Gnat, when ſhe is engaged in laying her eggs, and in a few days this produces a very ſmall Vermicle or Worm *. I was firſt informed that the Gnats ſprung out of the water by the curious and learned Mr. Duiſſen, a very vigilant proteſtant miniſter at Saumur in France, who had obſerved it in his kitchen garden, where there was a ſtone baſon with water in it, out of which he ſaw plainly that Gnats aroſe at a certain ſeaſon.

Afterwards, on my return to Holland, I found the Worm of the Gnat ſwimming in water, and immediately took its figure. Hence it happened, that when I ſaw it in the admirable figures of Dr. Hook's micrography, I immediately knew it, ſince that very learned Engliſh gentleman has delineated it with the greateſt accuracy. But this celebrated writer does not ſeem to me to have examined the tail of that Worm with ſufficient attention. I ſhall obſerve further, that the Nymph of the Gnat has been ſomewhat improperly exhibited by him, unleſs he had ſome other ſpecies of this inſect. This is the more probable to me, as I find there are various Nymphs of Gnats, as well as many kinds of the Flies themſelves.

In Tab. XXXI. fig. IV. I exhibit in its natural ſize the Worm out of which the Gnat is produced. The ſame is likewiſe repreſented in fig. V. magnified by a microſcope, and thus it preſents to the eye very obviouſly the conſtruction of its breaſt and body. It may be likewiſe obſerved here, in what manner it raiſes itſelf to the ſurface of the water by the help of its tail, and alſo the conſtruction whereby it is divided into the head, breaſt, body and tail.

In the head, which lies ſunk under the water, I have ſhewn in this figure various particulars particularly the eyes, the horns, and the lower part of the mouth. The eyes are black *a a*, and have a ſmooth and poliſhed ſurface; nor are they divided like a cluſter of grapes, or by an hexagonal network, as in many inſects, but are of a figure ſomewhat lunated or like a creſcent. The horns are ſhaped not unlike the collar-bones, Tab. XXXI. fig. V. *b b*, in the human ſpecies, and are furniſhed with hairs towards their ends. The opening of the mouth is likewiſe ſhewn here *c*, appearing like a blackiſh triangular ſpot. We may likewiſe diſtinguiſh by the microſcope ſeven other little parts of the mouth, whereof I exhibit three, as well above the mouth as at its ſides; but the ſeventh, which is ſomewhat brown, is obſerved to have its two baſes placed near the thorax, and reaching to the eyes. This little part is ſomewhat whiter in the middle, and grows browner a little lower near the mouth, but in the anterior or fore part, it appears to be formed like the nails of our fingers, or the ſcales of fiſh. Where this little part terminates with its brown curvature or winding, almoſt in the middle or lower region of the head, I exhibit the firſt of the three pair of little parts already named. This pair is of a triangular figure, on account of the hairs wherewith their inner ſide is ſurrounded. About the end of this follows another pair of the like little parts, the beginning of which are horny or bony, but the extremities are hairy. Below theſe again are ſeen a third pair of little parts which are ſomewhat thicker and more ſhaggy, and extend to the hairs of the horns. Theſe three pair of little parts are, properly ſpeaking, articulated briſtly hairs, which the Worm of the Gnat makes uſe of to direct the food to its mouth. I have before obſerved ſomething like this in the hermit Crab, in which I have deſcribed many little parts of a ſomewhat like kind. The mouth of this Worm is in the fore part beſet thickly with hairs, which are all of equal length, and are placed equally diſtant from one another: this is ſhewn at the letter *c*.

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* There is not in all the inſect world a creature more happily ſuited to ſhew the ſeveral operations of life than this. A moderate microſcope diſcovers to us very clearly what paſſes within its tranſparent body. The creature is at firſt greeniſh and ſomewhat dusky, but as it grows towards the change, it becomes pale and greeniſh. At that time the beating of the heart, and the motion of the ſtomach and inteſtines are perfectly ſeen, and the two principal pulmonary tubes may be traced along their courſe very clearly.

In the thorax are certain regular diviſions *d d*, which are produced by the growing and extuberant joints of the legs and wings of the Gnat within. Hence I can ſhew even in this Worm all the limbs and parts of the future Nymph, and of the perfect Gnat lying under the skin, as I ſhall do on a ſucceeding occaſion in the Worms of Bees, and ſhall thus exhibit an example applicable to all other inſects belonging to this firſt ſpecies, or method of the third order of natural transformations. Afterwards, when I come to the ſecond method of the third order, I ſhall preſent to the eye a kind of ſimilar inſtance on the diurnal Butterfly. We may likewiſe further obſerve how the thorax of this Worm is diſtinguiſhed with furrowed lines, and beſet on each ſide with briſtly hairs, many iſſuing together as it were out of one center.

The belly is divided into eight annular ſections, Tab. XXXI. fig. v. *e e*; to which, if you add the ſhaggy extremity *f* of the tail, and that part of it which is likewiſe ſtrengthened *g* with the briſtly hairs, and is extended by the Worm above the ſurface of the water, ten rings muſt be reckoned in the whole. In that part of the tail which is ſeen *b* above the ſurface of the water, there appear certain black ſpots, and ſome depreſſions or holes, as alſo many briſtly hairs. But here we muſt take particular notice, that whenever the Worm, ſwimming in the middle of the water pulls down the part of the tail juſt mentioned under the water, that part never becomes wet. Therefore, when the Worm wants to reſt, or ceaſe moving, it immediately goes up to the ſurface, and there, by means of its tail, ſuſpends itſelf almoſt in the ſame manner as we ſee a little glaſs figure of a man hang pendulous in a glaſſy bubble in water. This is done the eaſier by this Worm, becauſe its tail always remains dry: hence it is alſo obſerved that as ſoon as this appendage of the tail has again emerged to the ſurface, the water immediately flows away from it on every ſide. And one may diſtinctly ſee that a kind of baſon or hole is by that means impreſſed on the water, when the body of the Worm gravitates downwards; the water not being able to penetrate into the dry tail and its depreſſions, is ſtopt in its circumference: and therefore the Worm, in regard to the extremity of its tail, very beautifully ſwims in the water in the manner of an empty hollow glaſs. The like effect may be likewiſe produced by art, if a needle be drawn through a cork and put into the water; for the cork will then ſwim on the water, and in like manner make a conſiderable depreſſion in the ſurface.

Near the extremity of this tail I exhibit ſome bubbles in the water *i*; theſe are frequently ſeen, and they ariſe from the air which the Worm can at pleaſure emit there out of its body. I have ſeen that the Worm, in order to draw in the air, has raiſed its head out of the water. When it has happened that the tail had loſt its dryneſs, and the Worm by this means can no longer ſuſpend itſelf on the ſurface of the water, which is the caſe when it is bruiſed or handled too roughly; I have on theſe occaſions obſerved, that it put its tail in its mouth, and afterwards drew it back together with its hairs. In this method of proceeding the inſect reſembles water fowls, which, by drawing their quills through their beak, prepare them in ſuch a manner that they can reſiſt the water. They ſecrete this fat matter by means of a double gland which they have in their rump, in which this oil, which ſtrengthens the wings againſt the water, is generated and excreted, and they thence take it into their beaks. I have ſometimes covered anatomical inſtruments of ſteel with this matter, in order to keep them from ruſting, and have found that the ſteel continued perfectly defended from ruſt by means of it; and I think it would have greater effect, if one had a great quantity of it boiled and properly managed.

As this whole inſect is pellucid, I have here exhibited the two tranſparent pulmonary tubes which appear in the middle of the tail where it floats in the water. Theſe ariſe from the body near the thorax, and contain, Tab. XXXI. fig. v. *k k*, in them the quantity of air whereby the bubbles are produced. This inſect therefore breathes at its tail, in the ſame manner as the Worm of the Gad Fly. But this tail is not ſo abſolutely neceſſary for the Worm of the Gnat, that it cannot live without it. It only ſerves for its conveniency, and by its powers enables the Worm to reſt or hold itſelf ſuſpended on the ſurface of the water. Hence it is, that the tail is entirely deſtroyed and thrown off when the Worm caſts its ſkin and is changed into a Nymph.

As to the other part of the belly or tail, whoſe extremity is likewiſe ſhaggy, with briſtly hairs, I exhibit about it ſome ſmall lumps *l* of an earthy matter, which fall into the water and there melt away by degrees *m*. Theſe are the excrements voided from the inteſtines. We may likewiſe obſerve here the inteſtines themſelves, which contain theſe fœces, and are ſeen through the tranſparent belly, ſituated between the pulmonary tubes *k k*, and at length terminating in this other extremity of the belly which is the real tail. It is very ſingular, that in this Worm, not only the motion of the inteſtines, but alſo the propulſion of the excrements in them *n* may be ſeen through the integuments of the body. This motion of the inteſtines, the never-enough celebrated Dr. Hook firſt diſcovered. I obſerve likewiſe that theſe pellucid inteſtines appear ſometimes white, ſometimes black, and are ſometimes divided into little knots. This variety ariſes from the contents and excrements being more or leſs changed in them. Laſtly, I likewiſe ſhew ſmall hairs in the eight rings of the abdomen, three in ſome, and in others four, and alſo the ſquamous or ſcaly windings and conſtructions thereof.

When this Worm is arrived at its full growth, and its limbs having attained their due perfection, are ſwollen or filled with blood and humours, it throws or caſts off its old ſkin, and expoſes to open view all its hitherto hidden limbs and parts; this is when it is changed into a Nymph, which is delineated in its natural ſize or bigneſs in Tab. XXXI. fig. VI. and in fig. VII. as it appears magnified with a microſcope. In the latter deſign, the head, breaſt and belly may be more diſtinctly ſeen than in the Worm; nay, and the eyes alſo, and the horns, the trunk, the legs and the wings. All theſe parts are however fluid like water, and muſt in due time evaporate this moiſture in the water, to ſuch a degree as to acquire due firmneſs.

Leſt the delineation of theſe parts ſhould be obſcured by annexing letters to them, I ſhall ſhew them all in a leſs finiſhed figure, which I have added for that purpoſe. Before I begin, it muſt be particularly obſerved, that the head, which before in the Worm hung downwards towards the bottom of the water, is always raiſed upwards in the Nymph, and is likewiſe, by means of two tubes, ſuſpended on the ſurface of the water, in the ſame manner as the tail of the Worm was before. Hence, as the Worm then drew the air through the tail, being changed into a Nymph, it now breathes the air with its head through the tubes juſt now mentioned. Hence it is alſo obſerved, that the tail which in the Worm was protended upwards, lies in the Nymph ſunk under the water; and this is indeed a remarkable change in the inſect with reſpect to its manner of living.

One might take theſe tubes in the head for the horns which the Worm had before, and which are now, after caſting the ſkin, dilated and adapted to another uſe; but thoſe horns were ſituated nearer to the foremoſt parts of the head. The tail is likewiſe upon the change of its ſkin conſiderably altered; it has acquired in this ſtate a beautiful feather, to ſerve as a rudder, by the help of which this Nymph moves freely from place to place, and ſwims in a quite another manner than it uſed to do when it was in the ſtate of a Worm. Dr. Hooke has alſo obſerved this change of the Nymph, in reſpect to the manner of its moving and ſwimming, as appears from his Micrography. In many inſects, nay, particularly in theſe which belong to the ſecond mode of the third oder, it is obſerved that when they are changed into the Chryſalis they have a motion in their tail, though all the reſt of their body become wholly immoveable, as is alſo the caſe in this Nymph. We have fully treated of this in the beginning of this chapter.

On one ſide of the head in this deſign is ſeen an eye, Tab. XXXI. fig. VIII. *a*, covered a little on the upper part with a membrane, which inveſts the proboſcis or trunk, and this eye, is now divided into hexagonal and globular diviſions. Above this appears to be ſituated one of the antennæ *b*, divided into ſeveral black knots which are ſo many joints. The trunk *c* which is the Gnat's ſting, and which partly covers the eye, is placed with its ſharp point between the legs and wings. The legs *d d d d* are in a wonderful manner twiſted and bent, but eſpecially in the hinder part; and they are hidden between the wings, and appear plainly through the tranſparent ſubſtance of the latter. This I here exhibit delineated, that both the wing of this ſide may be ſeen, and alſo the membrane that inveſts it *e e*, and which is placed above the legs. The body is divided into eight rings, on which ſome of the hairs, that have changed their outer covering *f f*, are obſerved to reſt. Through the middle of the whole length of the body appears a beautiful border or riſing verge *g g*, which I could ſcarce diſcover in the Worm of the Gnat, nor have I afterwards found it conſiderable in the perfect Gnat itſelf. The tail, which hangs down, has, as I obſerved, a moving jointed fin *h*, by the help of which the Nymph removes from place to place. In the upper parts of the head are ſeen the tubulated horns *i i* before deſcribed, by means of which the creature, while in this ſtate, hangs and breathes on the ſurface of the water; but by the help of this conſtruction the Nymph is now better prepared to be changed into a Gnat after caſting its ſkin. This inſect, while in the Nymph ſtate, has no certain colour; for, upon its change, it grows white, and afterwards becomes ſomewhat green, and at laſt it approaches to black.

After this Nymph has lived ſome days, moving itſelf backwards and forwards in the water, and its tender limbs are ſtrengthened, it burſts and caſts its ſkin in the middle between thoſe two horns or tubes, by the help of which it was before ſuſpended on the ſurface of the water; and after this, on account of the lightneſs of its body only, it remains on the ſurface, until its wings are expanded and dried with air; then the Nymph having aſſumed the form of a Gnat flies away, leaving its caſt ſkin ſwimming in the the water, where it inſenſibly decays.

The Gnats of this ſpecies *, which are beſt of all known in Holland on account of their miſchievous trunk or ſting, are eaſily diſtinguiſhed into males and females. I exhibit the male in Tab. XXXII. fig. I. and alſo a microſcopic view of it in fig. II. Between this Gnat and its Nymph there is no other difference, except that the limbs are diſpoſed and placed in a different manner in the Nymph from what they are in the perfect Gnat. Hence, as the head, breaſt, belly, &c. may be ſeen and unfolded in the Nymph, we may diſtinguiſh all theſe things in the Gnat itſelf, but much more accurately, for the external ſkin of the Nymph, which prevented the more diſtinct view of all theſe parts, has been now, upon the laſt change, thrown off.

In the head of the male Gnat, I particularly exhibit, in the enlarged figure, the eyes, horns, and trunk; as alſo two other parts placed near the trunk or ſting, between or under which the latter is properly placed: the eyes *a a* conſtitute the greateſt part of the head, as is the caſe in many other ſpecies of inſects. They are of a greeniſh colour, and they form as it were an hexagonal piece of network, the diviſions whereof riſe in a globular figure. Near the eyes I repreſent the horns *b b*, which ariſe as it were out of two yellowiſh fleſh-coloured little globes, and are beautifully divided into twelve black knot-like joints, which are ſurrounded with hairs like tender flaxen threads. Toward the extremity of each of theſe antennæ is ſeen a circle, conſiſting of ſix hairs placed in a circle; above which appear the extreme ends of the horns ſurrounded or covered with yet ſmaller hairs. As to the other two long and crooked parts, between which the trunk or aculeus is obſerved to be ſituated *c c*, I find them divided into three joints, beſet with hairs toward their extremities, and moreover covered every where with a kind of browniſh feathers, which reſemble, as the feathers of Butterflies do, the little ſcales of fiſhes.

The trunk is of the ſame colour, and is adorned *d* with the like ſcaly little feathers, but it is not divided into joints, being immoveable in the middle; though there are plainly ſome diviſions toward the end of it; and it is there likewiſe near the end regularly ſurrounded by five hairs on each ſide of it. On full conſideration of the whole, the part before deſcribed, and which we uſually call the trunk *e*, the aculeus or ſting of the Gnat, is nothing more than a ſheath or caſe of the real ſting *e*, which is repreſented in this figure only projecting, or as if thruſt, out of it. This ſting is provided with ſo ſharp a point, that I could never obſerve the leaſt breadth therein, with the beſt microſcopes that I uſed in the year 1688. If you put the edges of the ſharpeſt razors, or the points of the fineſt needles and lancets before the microſcope, you will eaſily ſee that they have viſible breadth, and appear blunt, ragged, and dull. I do not find this ſheath in all Gnats; and this is the caſe in that ſpecies deſcribed by Goedaert, the ſting of which I ſhould incline to think is very ſhort, and lies rather in the mouth than in any ſheath or caſe; ſo that the ſame thing ſeems to obtain here as in the Louſe kind, the ſheath and trunk of which are alſo diſcovered with difficulty, though theſe little creatures prick or ſting vehemently, and give us great trouble by ſucking our blood.

Thus I obſerve, with reſpect to other inſects, that there is great difference as to their ſtings and trunks; ſome of them have their proboſcides eight times longer than others, beſides that the conſtruction differs greatly in both. But I have elſewhere ſaid enough on this ſubject, when I treated of the ſwift Butterfly, which is repreſented in the hiſtory of the Rhinoceros Beetle, Tab. XXIX. But when I come to the Gad Fly I ſhall, from the obſervations I have made on the ſting and trunk, offer ſome reaſons why many inſects that feed on blood, ſtill preſerve life, through deprived for a long time of the blood wherewith they naturally nouriſh themſelves. This queſtion may certainly ariſe with reſpect to Bugs, Fleas, and ſeveral ſuch inſects, and alſo in regard to the Gnat kind. I now return to the ſubject and ſhall give a more full explanation of the trunk of the Gnat.

The caſe or ſheath of the ſting, as I have already obſerved, is immoveable in the middle, but where it is united to the head it appears to be jointed. If one diſſects it under the microſcope, and very quickly breaks it off at a little diſtance from the head, or cuts it, Tab. XXXII. fig. III. *a*, in its circumference, but in ſuch a manner, as at the ſame time to draw this broken caſe of the ſting from the ſting itſelf, which is placed on the inſide; this way at length the aculeus is plainly ſeen naked and diſengaged from all impediments, in which ſtate it could not be viewed before. When I firſt made this experiment, I thought I had diſcovered the whole aculeus in this manner: for I obſerved an acute pellucid little part of a bright red colour *b*, which conſiſted of a horny or bony matter, and was moderately ſtrong and yet flexible. But upon examining this little part afterwards with a larger magnifying glaſs, I obſerved that there was a conſiderable aperture juſt below its ſharp point; and I alſo obſerved two little drops of a real liquor, at ſome diſtance from each other, lying in the middle of this little part, as in a little hollow tube. As I was attempting to expreſs or get out this liquid under the microſcope, it happened, contrary to my expectations, that I broke that little part. This accident had great advantage, for on the inſide of this little part I then diſcovered five diſtinct aculei or ſtings, and conſequently thus found the whole conſtruction of the aculeus.

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* We have in England three very diſtinct kinds of Gnats: the largeſt of theſe has brown eyes, and a black and white body; the middle kind is altogether brown: this has the moſt miſchievous bite of any. The third or ſmaller kind has a red breaſt; this alſo bites ſeverely. The Worms of all theſe are alike in form, and, what is very remarkable, they differ little in ſize. We have beſide theſe a multitude of diſtinct ſpecies very ſmall, which are, in the fen countries, very troubleſome.

I obſerved that two of theſe aculei which were hidden within the tubulated little canal of the general thing were, much more ſlender, Tab. XXXII. fig. III. *c c*, than the three others, which appeared thicker and ſtronger, *d d d.* I likewiſe obſerved that they were ſomewhat broader where they were articulated with the head, but that they afterwards became ſmall, and that they were finally conſiderably extended, before they terminate in their delicate and fine points. All theſe aculei were of a delicate ſmooth ſurface, but in the middle they were ſomewhat thicker and more diſtended, ſo that in that part they appeared of a browner colour, exhibiting to the eye within a pellucid bright redneſs: but they conſiſted of a flexible horny or bony matter like that of the little canal which contained them. I could not diſcover any cavity in them, though there ſeemed to be ſomething of this kind in the larger; for when theſe were examined with a very acute glaſs, they curled and continually moved about: this, I thought, muſt be attributed to the evaporation of the humour incloſed or contained within their ſubſtance. I could by no means, however, obſerve any other mark of their being hollow on the inſide.

As to the uſe of theſe five aculei, they ſeem only to ſerve as ſo many very ſharp lances to enter the pores of the ſkin, and afterwards to retract or draw themſelves back into the inward caſe wherein they are kept: but then I ſhould think that the acute and hollow extremity of this caſe is certainly introduced into the wound, and by means thereof the Gnat afterwards ſucks the blood, which, running or aſcending by ſuction between theſe ſharp parts, is at length conveyed into the body of the inſect. Hence there appears almoſt the ſame uſe of this ſheath as there is of the ſilver pipes uſed by our ſurgeons, through which they paſs their lancets when they are about to open ulcers that lie deep between the jaws, and are careful to wound no other parts but thoſe they are to cut. The reaſon why nature hath made five aculei for this purpoſe, is, I confeſs, beyond my comprehenſion, unleſs one ſhould incline to think that by the repeated agitation of ſo many things in the womb, the blood is better prepared to aſcend through this long and moſt ſlender tube wherein thoſe ſtings are hidden.

I am firmly perſuaded that when the Gnat has no opportunity of drawing blood out of animals, it ſucks, with the help of its caſe, the juices of flowers, plants or fruits, being content with feeding on the latter when it wants the former: indeed, by what other means could it ſupport itſelf, when it lives in the fields and woods? I would not now preſume to affirm for certain, whether, when I firſt communicated to the public the figure of the Gnat's trunk, not knowing then that it had five ſtings, I ſaw one or more ſtings projecting or hanging out of its caſe; but I am not certain now that theſe five ſtings, viewed ſideways, do not appear broader in the fore part next under their points than elſewhere.

After I had made the obſervations already mentioned on the ſting of the Gnat, I often afterwards obſerved in the dead Gnats, that all their ſtings were broken off from their caſe, and appeared without the little tube, without my aid. And hence I began to conſider, whether theſe integuments of the five ſtings reſemble or not the ſheath or caſe of a Bee's ſting, and only or looſely contain the real ſting, as a ſcabbard open on one ſide might hold a ſword. But, notwithſtanding the repeated pains I have hitherto taken to diſcover the truth in this matter, yet I could never find out any mark of ſuch a ſtructure. I therefore think I may ſafely maintain that both the caſe of the ſting and its inward pipe are two diſtinct and entire integuments, the exterior of which contains the little tube, and the interior, which is the little tube itſelf, contains the five ſtings.

It has ſometimes happened, that upon examining theſe things in other ſpecies of Gnats, I have obſerved that, like the ſtings of Bees, they were provided with a kind of crooked claws, or were at leaſt ſerrated on their ſurface. But this I had not the good fortune to ſee when I was engaged in drawing and finiſhing the figures of theſe parts from the preſent ſpecies; only I thought I once ſaw ſomething like it through the common microſcopes, and therefore thoſe who are fond of microſcopes, muſt take care not to confide in one lens or glaſs only, and muſt not always view the object in the ſame manner and ſituation, for by this means many errors ariſe. In the third figure above mentioned is likewiſe ſeen the neck, Tab. XXXII. fig. III. *e*, of the Gnat, and the head *f* placed thereon, in which the eyes *g g* appear, as alſo the antennæ cut off *h h*, and the articulated ſetae *f* or briſtly hairs *i i*, which are cut off above the ſtings.

As to the thorax of the Gnat, it carries the legs and wings, and alſo two little parts like hammers, and of an oval figure. The legs are of a browniſh colour, and conſiſt of ſeven joints, fig. II. *f f f f*, which are larger in the hinder that in the fore legs: but beſides theſe, the extremity of each leg is likewiſe armed

with

with two claws. Moreover, the legs of this inſect are all over covered with ſcaly little feathers, between which appear ſome blackiſh ſetaceous hairs.

The ſtructure of the wings *gggg* is ſo beautiful, that nothing can, in a manner, be invented more ingenious or artificial. They conſiſt partly of pulmonary tubes, and partly of delicate membranes, which are perfectly pellucid. They are of an oblong form, and of a glaſſy colour; but they are obſcured or ſhaded by a very great number of ſcaly rhomboidal figures, which are a vaſt ornament to them. All the membranes of the wings are interwoven with pulmonary tubes, which run through them like ſo many veins and nerves; and upon thoſe pulmonary tubes, which are conveyed out of the body into the wings, are fixed theſe oblong and broad feathers for the ſake of ornament. The ſame conſtruction is ſeen alſo in the beginning, middle, and circumference of the wings, and is a very agreeable ſight. In order to make this ſtructure clear or more evident, I here exhibit the wings ſomewhat larger, in proportion to the other part of the Gnat, than they were formerly. But if theſe wings were repreſented as large as they can poſſibly be magnified by good glaſſes, the divine miracles that are preſented to us therein would amaze all mankind.

We ſhould then diſtinguiſh clearly that every ſeries of the little feathers before deſcribed, likewiſe reſts on a ſtalk or tube, by means of which, it is united to the pulmonary tubes: and alſo, that ſome of the feathers are here and there larger, ſhorter, or broader, and placed in a quite different manner from the reſt, as far as regularity and beauty would admit. If broken feathers chance to occur any where, their quills will be found there ſtill fixed in the pulmonary tubes. The ſtructure of the little feathers would ſhew itſelf very admirable in this caſe, for almoſt all of them are interwoven with ſix regular little ribs like ſo many nerves, each of which conſiſts of a great number of regular globules. This is ſeen more clearly by the help of a powerful microſcope; all theſe little feathers being likewiſe tranſparent, though they are not altogether ſo clear as the membranes of the wings.

Further we may obſerve, in what a wonderful manner the very membrane of the wings is conſtructed in this creature, for it appears under the microſcope beſet with many prominent papillæ or little riſings. If this part be viewed by help of the moſt powerful microſcope, it will be diſtinctly ſeen that all theſe papillæ are ſo many crooked, curled, pellucid little tips or points, of moſt delicate, long or extended papillæ. In all this the omnipotence and wiſdom of God ſhines brighter than the meridian ſun. All theſe things cannot be expreſſed in the ſmall compaſs of a ſingle figure. I have therefore exhibited upon this membrane of the wings, only a few out of the great number of theſe inflected and ſharp-pointed papillæ in the form of points. Nay, I would venture to aſſert, that however good the microſcope made uſe of is, yet one cannot ſee theſe papillæ diſtinctly, unleſs we firſt tear a part of the membrane of the wings carefully for that purpoſe; for the ſharp little tops or points which I have here mentioned, are only to be ſeen when all impediments are moſt carefully removed.

The malleoli, Tab. XXXII. fig. II. *h h*, or little hammers fixed to the breaſt, whereof I made mention, are of a ſomewhat irregular ſhape, and at their extremities are conſiderably dilated: they are there ſmooth and of a whitiſh colour. I have obſerved ſuch malleoli almoſt in all Flies which have only two wings. The ſurface of the thorax alſo ſhines a little, and being covered in a manner with red briſtly hairs, inſtead of feathers, it is likewiſe adorned with a red colour.

The belly is divided into eight rings *k k*, in the ſame manner as I have exhibited in the Worm and Nymph. All theſe diviſions are likewiſe as viſible in the perfect Gnat, as in thoſe ſtates lately mentioned. I further, obſerve that the belly and tail are every where covered with feathers, which are black in ſome places; and this is the reaſon that the belly and tail appear divided as it were by black rings. The other little feathers intermixed with the former are of a white or yellowiſh colour, and are wholly tranſparent. Moreover, the whole belly is every where covered with fine hairs, the extremities of which curl, and ſeem to be in ſome meaſure entangled in one another, though in reality they are not.

I alſo repreſent the head of the female Gnat, fig. IV. magnified, which, in reſpect to the ſtructure of the horns, differs from the male's head *a a* extremely. Thoſe little parts of the head alſo, between and under which the ſheath of the ſting is extended, are much ſmaller in the female, and diſtinguiſhed with greater difficulty *b b*. The horns in this ſex are alſo divided as it were with twelve parts, and they are regularly covered with browniſh hairs and little feathers. The ſheath of the ſting *c*, and the other little parts are of the ſame ſtructure, and have the ſame integuments that I have before deſcribed in thoſe of the male. Laſtly, that nothing may be deficient, I likewiſe exhibit the female herſelf in her natural ſize, in fig. V. I have not yet accurately inveſtigated the internal parts of the Gnat, and therefore ſhall ſay nothing of them here.

I have occaſionally obſerved many diſtinct ſpecies of Gnats, but their principal difference conſiſts in this, that ſome of them have and others have not a ſting or trunk, and therefore ſeem to be harmleſs. They likewiſe differ conſiderably among themſelves in reſpect to their magnitude, colours, and food; the place wherein they live, and the manner wherein they are produced; and in ſeveral other particulars worthy attention. At preſent I ſhall ſay nothing more of theſe inſects, being already too much fatigued with obſerving and deſcribing thoſe particulars, which I have hitherto advanced. I ſhall therefore conclude this treatiſe, and proceed to the hiſtory of Bees.

A TREATISE on the

HISTORY of BEES;

Or an accurate deſcription of

Their origin, generation, ſex, œconomy, labours and uſe.

O come hither, and behold the works of God: how wonderful he is in doing towards the children of men. Pſal. LXVI. 5.

INTRODUCTION.

ALTHOUGH the majeſty of the immortal God is in its nature inacceſſible to mortal eyes, his eternal power and divinity are moſt clearly and evidently ſeen in all created beings: ſome creatures, however, preſent the inviſible God to our contemplation more plainly than others, as will appear from the ſubſequent treatiſe. Since, therefore, the moſt wiſe and great God has been graciouſly pleaſed to bleſs and crown my indefatigable and aſſiduous labours with ſome degree of ſucceſs, I hope that his infinite power and immenſe wiſdom, as well as our own weakneſs, will be thereby made clearer than the light at noon; ſo that whoever peruſes this treatiſe, may find matter enough of wonder, and be led to proclaim and admire the magnificence and wiſdom of God, and to bleſs his inexhauſtible bounty. If theſe pages, which only exhibit as it were the ſhadows of things, and extremely defective deſcriptions of the ſecrets works of God, that are impenetrable and impoſſible to be fully inveſtigated, ſhould direct the reader to this true uſe of the reſearches, I ſhall think the pains I have taken, not only recompenſed, but alſo ſufficiently proſperous and bleſſed by the divine grace.

If any one accurately conſiders the diſpoſition and ſtructure of the ſmalleſt and largeſt animals, and compares them one with another, he will ſee that they agree not only in the above mentioned particulars, but alſo in that they ſpring from like principles, which are eggs of their parents, as well in the ſmalleſt as in the largeſt animals: and as theſe eggs increaſe and are perfected, as it were from very ſmall and almoſt inviſible points, they, in the ſame manner, come to the full period of their increaſe in the ſmalleſt animals as in the largeſt. Nor is there any creature excepted from this univerſal law of its origin. Since man alſo, the moſt noble of all creatures, and who is a rational animal, has his origin or beginning from an egg, and therefore cannot, in reſpect to his firſt principle, prefer himſelf to the ſmalleſt inſects, or, with regard to his natural diſpoſition and ſtructure, aſſume to himſelf any ſuperior dignity, in preference to the moſt mean and contemptible creatures the Louſe or Mite. That this is moſt certain in regard to the human ſpecies, I have learned from experiment, in the year 1667, as did alſo the celebrated Van Home. This may be ſeen in my book intitled, the miracles of nature. Further, it deſerves notice, that as to the principles or rudiments of ſmaller as well as larger animals, the former are more conſpicuous, and more clearly diſcernible in their firſt ſtate than the latter. And further, ſince God hath preſcribed certain limits of magnitude to the ſmaller animals, beyond which they cannot increaſe, and which limits are probably ſituated in the peculiar ſtructure, or from the weakneſs of the heart, by the power of which all the other parts muſt be extended againſt the gravity of the atmoſphere; the ſmall animals, therefore, while in embryo, may be much more perfect than the larger.

To come nearer to my purpoſe; as I propoſed in my book of inſects publiſhed in the year 1669, at ſome other time to treat expreſsly on the ſtructure of inſects, and in that work to give the particular hiſtory of Bees; ſaying, by way of anticipation, that the king, as commonly called, was a female, the drone a male, and that the common Bees belonged to neither ſex; I ſhall, to keep my promiſe with the publick, now treat particularly of the ſtructure, diſpoſition, and principles or rudiments of theſe three creatures, which are different in themſelves, but of the ſame ſpecies. I ſhall alſo occaſionally interſperſe ſome other obſervations on the parts of ſome other inſects, the whole conſtructions of which I ſhall, with the divine favour, at ſome other time deſcribe more at large.

On the twenty-ſecond of Auguſt 1673, I opened a Bee-hive, after the Bees had ſwarmed, I found ſome thouſands of common Bees in it, ſome hundred drones, and one king. But as, properly ſpeaking, neither king nor drones are to be found in the hives, as has been already obſerved; and ſince it happened, through a very great and inexcuſable error, that thoſe wrong names were given to thoſe creatures, I would therefore here in the beginning inform the reader, that through this whole treatiſe I ſhall call that pretended king by the name of the female Bee; and to that which is commonly called the drone, I ſhall give the title of the male Bee, and the common Bees, I ſhall, for diſtinction's ſake, denominate working Bees: I ſhall alſo in the following pages, ſhew the very clear and evident reaſons which have induced me to make this innovation.

When I had opened and deſtroyed a hive at the time above-mentioned, beſides the males, females and working Bees, I found therein three different ſpecies of cells, or little houſes of the inſects, which are called by the general name of honey-combs. In ſome hundreds of theſe cells the males were fed and grew, in ſome few, females were generated; and in the reſt, of which there were ſome thouſands, the common Bees were nouriſhed, brought up, and finally changed. The cells of the males and females were are this time empty, but the cells of the common Bees, though they ſeemed for the moſt part empty, were many of them really full and covered with wax. When I broke theſe cells open with a ſmall needle fixed on a ſkewer, I found ſome of the Worms of the Bees placed upright without any motion. In ſome other cells that were covered in the ſame manner, there were Nymphs or Worms of Bees, which, by due accretion, had already acquired the form of Bees, and were to be let out from thence. In others I found honey. The reſt of the cells were open, and not covered or ſealed up; and ſome of them had eggs, others contained Worms very lately hatched out of their eggs, and provided on every ſide of them with food: others again had larger Worms; and finally, others were arrived at their full bigneſs. Theſe are called the offspring or ſtock, by the keepers of Bees in our country, and they had yellow excrements under them.

In the middle between theſe eggs and the ſtock, were ſeen ſome little cells alſo ſealed up, which, when I opened, I found filled with honey; for the Bees never leave any place empty in their hive, but as ſoon as any Worm is changed into a Bee, they immediately fill its cell with ſomething elſe. Therefore, if the combs in the upper part of the hive are firſt emptied of the young Bees, they firſt put their honey into them; but if thoſe in the combs in the middle of the hive become mature before the others, they firſt fill them with honey: and laſtly, when the combs of the loweſt part of the hive are emptied, they in the ſame manner fill them before the others with honey: but they afterwards carry the honey repoſited there to the upper part of the hive. This Clutius obſerved, but I have not yet ſeen it. The Bees proceed in this manner, when the year is fruitful, in order to ſhorten the time, ſo as to enable them to gather the more honey, or when they are more numerous in the hive; for then they immediately lay the honey as ſoon as there is room, and afterwards, when the time of making honey is paſt, they carry it elſewhere.

This hive, therefore, as a common and fraternal habitation, contained the rudiments and ſtock, the males and females, with their labouring ſervants, that is, the common Bees; and laſtly, plenty of food. Therefore it was well provided and prepared to bear ſecurely, and, in a regular order, the inclemency of the approaching winter. The order under which the Bees that live in the winter months conduct themſelves is this: they firſt open the cells and eat the honey depoſited in the loweſt part of the hive, aſcending by degrees up to the upper parts. This they do in order to preſerve a mutual warmth between them; and the female depoſits her eggs in the little cells as they are emptied. Therefore about the beginning of March I diſcovered the ſtock and the Nymph. Let no one be ſurpriſed at this, ſince towards the beginning of Auguſt I have ſeen ſome thouſand eggs encloſed in the ovary in the female's body; ſo that it is natural for the Bees at any time of the year to lay their eggs, and increaſe their family. Bees are not therefore confined to the time of ſwarming in regard to the buſineſs of generation; indeed, they are always at this work, ſince they loſe ſome of their fellow-citizens by the injuries of rain and winds, and other inconveniences and diſorders; in the place of which they are obliged to ſubſtitute young ones by a continued generation.

Our keepers of Bees are wont to expreſs by the following proverb, how ſoon the young Bees are hatched, when they ſay, that the firſt Swallow and the firſt Bee give notice of each other *. There are ſome, indeed, who think this ſhould be underſtood of the flying off of Bees, but this does not ſeem to be the proper ſignification of the proverb.

We muſt obſerve here, that ſome of the cells in the hives are filled with a matter of various colours, which has been gathered and

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* Among the wonders in the real œconomy of Bees, nothing more deſerves our attention than the certain preſage they have of rain. It has been ſuppoſed they ſee clouds gathering for it, and know where they will fall, but their eyes are not made for ſo remote objects It is certain they have ſame notice, and that it never deceives them. They haſten to the hive and get in before the moſt ſudden ſhowers. One never ſees a Bee in the rain, unleſs it be a lame or diſabled drone. In all probability they feel the temperature of the air which brings rain; and if we obſerve the amazing ſtructure of their pulmonary tubes, as deſcribed by this author, there will appear no wonder that they feel very ſuddenly all changes in the atmoſphere.

laid together as it were into ſtrata or beds, like Herrings or other merchandize put with great art into a barrel, which are by degrees and at different times heaped upon one another. This matter I found on examination was granulated, and taſted ſomewhat ſweet. Some of the cells containing it were ſealed up, and others open and only half full: others were ſcarce begun filling, and in others again began to decay. This ſubſtance is called by the Bee-keepers the bread or food of the Bees, wherewith they are ſaid to cure themſelves when they have a flux. But as credulity is often the parent of error, doubting about the truth of that received opinion, I have by various methods ſearched into and examined this ſubſtance: for it ſeemed to be rather the rudiment of wax. I have therefore firſt thrown it into water, in which it was quickly broken and diſperſed, but it always remained in grains: this likewiſe happened when I put it on my tongue. If it be put on a piece of thin glaſs, and placed on a red hot coal covered with aſhes, I have obſerved that by degrees it waſted, grew dry, hardened, and at laſt become black. Nor does it ever melt when thus placed on the fire; nay, if it be thrown naked into the fire, or applied to a burning candle, it never burns. From theſe experiments it ſeemed to me not at all to conſiſt of the matter of fat, for the ſake of examining which I had begun them, eſpecially ſince I obſerved, that it was very like that ſubſtance which the Bees conſtantly carry home, and is fixed on the fifth joint of their hinder legs, and which is taken for wax by all the Bee-keepers. Upon examining this matter which the Bees carry on their legs, I diſcovered that it is abſolutely the medicinal bread of the Bees. Hence it came to paſs, that I could ſcarce perſuade myſelf that the Bees carry the wax perfect out of the fields without any previous preparation; as I cannot be hitherto brought to believe any thing like it of honey, being rather of opinion that this is transformed into a better united and thicker liquid, by digeſtion in the ſtomach of the Bees: though it may, however, be poſſible that in the fruitful and hotter ſummers, the Bees may collect the honey as they find it prepared by nature in flowers into the cavity of their trunk: as the trunk is full of irregular parts, and as it were ſet or planted with glandules; hence it follows that the honey may likewiſe ſuffer ſome change in it. As to the wax I do not doubt but it is prepared by the Bees. However this matter may be, when I afterwards laid theſe doubts before the moſt intelligent Bee-keepers, they were all unanimouſly obliged to allow that no difference could be obſerved between the bread or food of Bees and the wax, which the Bees had carried freſh into their hives *.

I therefore mixed this bread, as it is called, with honey, in order to ſee whether I could gather any thing from thence, but the event of the experiment taught me that I had laid too great ſtreſs on theory. In the beginning, indeed, when it is firſt mixed, it becomes a very clammy and glutinous maſs; and it runs more thin than the honey did before, and becomes ſtill more ſoft when expoſed to the fire: but when it ſuſtains the force of the fire a little longer, it ſoon diſcovers its former nature. It likewiſe breaks in water, nor does it much recede from its former nature or diſpoſition.

From that experiment I am inclined to believe that this is the ſubſtance from which the Bees prepare their wax. But I think they do this buſineſs by the help of their ſaliva or of the execrated and digeſted honey. And hence though what is commonly ſaid may probably be true, that Bees uſe this matter as a medicine; yet I do not doubt but they gather it in the time of plenty, that when ſcarcity comes, or when wet and cloudy weather approaches, or when they cannot from any other cauſe fly out of the hives, they may take their time to perfect it. Any one may know by an eaſy experiment whether this matter be ſo. The Bees therefore ſeem to behave with reſpect to this, in the ſame manner as they uſually do in regard to honey, of which they gather more than they have immediate occaſion for, that they may live thereon in the time of neceſſity. This abundant quantity amounts to ſometimes thirty, forty, fifty, or ſixty pounds. Nay, their zeal and earneſtneſs to gather honey urges them ſo far, that they ſometimes throw their ſtock or young out of the hives and fill the emptied cells with honey: but I ſhould think there is ſome other reaſon for this act, which yet remains to be conſidered and diſcovered.

I think that the Bees probably gather this matter in order to form and perfect it into wax in the times of ſcarcity, to cover up the little cells of the combs therewith, and to faſten it on the webs of the ſpinning Worms. This I ſhall afterwards explain more at large. I am likewiſe inclined to think that this matter ſerves alſo to cloſe up the door or opening of the hive when winter approaches, or at leaſt to make it narrower by way of defence againſt the inclemency of the cold: unleſs one ſhould think it more probable that they ſeparate the matter they uſe for this purpoſe from the reſt of the wax, or gather this peculiar glue from beech and poplar trees; with which, as the Bee-keepers ſay, they afterwards not only make the door or opening narrower, but alſo cover all the lower part of the hive itſelf,

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* The French give with great propriety the name Bees-bread, Pain des Abeiles, to the farina or duſty ſubſtance lodged in the antheræ of flowers. It is certain that they eat this, and that it is afterwards converted into wax in their ſtomachs, for they collect vaſt quantities of it when they have no combs to make, and uſe it merely as food.

and plank it, and make a regular margin or border on the inſide [*]. The bread of the Bees appears therefore, in the opinion of the Bee-keepers, to be ſomewhat different from the wax; but in my opinion it is the very matter or ſubſtance of the wax itſelf, not yet prepared. In order to view and inveſtigate the ſtructure of the Bee-bread, nothing is more proper than to make uſe of a microſcope in the manner following: the Bee-bread is to be put into a glaſs full of clear water, and then ſhaken a little, in order to ſeparate it into a fine duſt; and when this does not ſucceed quick enough, it may be accelerated by breaking it with a ſmall fine pencil. This duſt is afterwards to be put upon a very thin piece of glaſs, as near as poſſible to the flame of a lamp; then the glaſs is by a little ſtarch to be faſtened to a ſmall piece of cork, which is afterwards to be fixed on the point of a needle and put under the microſcope. Thus it will be found that the Bee-bread conſiſts only of fine globules of equal form and magnitude; they have commonly three or four corners, but they are often alſo round: this angulated figure may probably be owing to the ſolidity and compactneſs of thoſe little parts, which the Bees bring them into with their teeth: between theſe little parts are found ſome yet more minute ones. But though the particles of which that bread conſiſts are very fine and delicate, yet one may, not the leſs manifeſtly, perceive them upon the tongue; for when this Bee-bread is taſted or chewed, it feels like a fine ſand in the mouth, or as ſugar undiſſolved, or divided only into little grains or angular little cryſtals. Moreover, when that bread breaks to pieces in water, it never diſſolves; but the parts conſtantly retain their former figures, and are only ſeparated and parted from each other. But whether theſe globules, when worked into wax, are ground, chewed or broken with the Bee's two teeth, and mixed with the ſaliva; or whether they are mixed with the fat or poiſonous liquor of the Bee's ſting, in order for forming the wax, is a matter which ſtill remains to be inveſtigated.

It is wonderful that the fat both of men and beaſts alſo conſiſts of ſuch minute grains and particles, which when any perſon has a mind to ſee them diſtinctly, he muſt manage and view it in the manner abovementioned. The fat cannot be ſeparated by water into ſmall parts, and therefore in order to break it ſufficiently, it muſt be ſhaken a little in ſpirit of wine: for thus it will very eaſily divide into minute globules. If it be afterwards put on the glaſs and examined in the manner beforementioned, it makes a very agreeable appearance.

This contrivance, wherewith we unite together ſuch fine and ſmall things, put on glaſs that they may be afterwards, when dry, viewed with a microſcope, I here mention for no other reaſon but becauſe it anſwers on many occaſions: for a great many things which could not be otherwiſe examined, are by this means very eaſily diſcovered, as will be made more evident in the following pages.

To return to the Bee-bread, we muſt obſerve that many ſpecies of Mites ſeek after it; and thoſe inſects are alſo fond of unmelted fat. This may probably be owing to the many ſkins the fat is ſurrounded with; which are conſumed in the melting, and which in the natural ſtate principally ſerve thoſe creatures as their food. One may ſometimes obſerve certain globular particles in that wax, with which the little cells of the Bees are ſtopt, and as it were ſealed up: and by this new argument the opinion which I have before propoſed, that the Bee-bread is really of the ſubſtance and nature of wax, is confirmed. When wax has been for ſome time ſteeped in ſpirit of wine, it becomes very brittle, and ſeparates into little particles, which ſeem alſo to be ſomewhat like the broken or divided bread of Bees; but that experiment ought to have been made with virgin wax, which I could not yet do, having been otherwiſe engaged.

Notwithſtanding all theſe things, we ſometimes ſee that the Bees carry real and perfect wax into the hives. This is compoſed likewiſe of globules; but they are four times, ſix times, nay, often ten times larger than the grains of the Bee-bread: theſe globules are likewiſe of an irregular figure. The Bees, no doubt, ſteal this wax, and bite it with their teeth from the wax made by other Bees; and afterwards fix it on their hinder legs in order to carry it into their hives. Therefore theſe little lumps are agreeable to the meaſure and magnitude of their bite, or are proportioned to the quantity which the Bees can take off a cake of wax, when ſoftened by the ſummer heat.

But if we attentively conſider the experiments that have been hitherto explained concerning the Bee-bread, and at the ſame time attend to its granular compoſition, it does not ſeem very probable that the Bees can live on it as their food in winter; for the Bees can take into their bodies only a matter that is not thicker than the honey itſelf, ſince they have a very narrow and ſlender trunk. Therefore, the Bee-keepers always reject granulated honey, or that which is cryſtalized or concreted into lumps, as unfit for feeding of Bees, nor do they ever give it to them to eat; but in winter time they fill ſplit elder ſticks with liquid honey, and draw them through from one ſide of the hive to the other. If any perſon ſhould object that the Bees can bruiſe or grind this bread with their teeth, and afterwards ſwallow it; the anſwer is, that the Bees can do the ſame with the granulated honey. My difficulty, therefore, ſtill remains unſolved, unleſs any one ſhould imagine that the Bees grind or bruiſe the grains of this bread in their jaws, and then, after mixing them with the ſaliva, or with freſh honey, by that help, attract and ſuck them through their narrow trunk; ſince, beſides this, they have no other paſſage into the body for this purpoſe. From theſe reaſons I am the more confirmed in this opinion, ſince the orifices of the trunk in Bees are ſo imperceptible, that they do not ſeem to me to be larger than the mouth of the meſeraic veins, or lacteals, that open into the inteſtines, and which will admit only very thin liquids, and ſuch as are purified to the higheſt degree.

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[*] Beſide wax and honey, the Bees collect a certain reſinous ſubſtance, which authors call Propolis. It is of a browniſh red colour, very clammy, and a perfect vegetable reſin. They uſe this to ſtop up holes or cracks in the hive, and to ſtrengthen weak places. It is not of the nature of wax, for it will diſſolve in ſpirit of wine; and we are not certain from what plants, or parts of plants they get it. The ancients were acquainted with this ſubſtance, but they ſay it was of a diſagreeable ſmell; with us it is aromatick. Probably the ſcent varies according to the plants whence it is obtained.

We might further ask how this Bee-bread acquires its roundiſh figure? alſo, whether it be dew, or whether the effluvia of flowers and fruits, firſt reſolved into vapours and afterwards condenſed in this form? or, finally, whether it has its origin from any other concreted fluid, reduced to a globular form by force of the incumbent atmoſphere? we have not yet ſufficient experiments to determine theſe matters; for, as Bacon juſtly obſerves, we muſt not feign or deviſe, but find out and diſcover what nature produces, and how ſhe operates. Something like this preſents itſelf to our view in nature, as may be obſerved particularly in gums; between the petals of the flowers of hops, there are alſo ſeen a great number of ſuch granules which are of a bitter taſte.

My honoured father, the ſooner to have ripe grapes, brought ſome vine branches into a little ſhed, built in his garden for that purpoſe, making openings in the windows to let them in. I obſerved that about theſe branches there was often an infinite number of white pellucid cryſtal-like globules, which were ſomewhat moiſt and clammy; nor could I ever melt thoſe particles, or reſolve them into vapours, becauſe there always remained ſome matter from them, which hardened in drying. This I mention particularly, that I may be able to explain with greater accuracy the nature of that peculiar mouldineſs to which the Bee-bread is ſubject; for though this mouldineſs appears to be compoſed of hairy, or feather-like, or downy little parts, or, as the celebrated Dr. Hooke has delineated in his micrography, of a peculiar kind of minute plants, yet it really conſiſts of an accumulation of globules that are ſome bigger than others. This was firſt ſhown me at Delphos by the induſtrious Leuwenhoek, by the help of a microſcope conſtructed after the model of that invented by the honourable Mr. Hudde conſul at Amſterdam. And therefore as to this matter, I think that bodies when they contract mouldineſs, emit only effluvia and vapours, which are propelled forward by force of the fermenting and heated matter; and which, being again condenſed by the colder atmoſphere, put on a globular figure, becauſe they are on every ſide equally ſurrounded by the incumbent air; and as whilſt ſome of theſe globules are following others, and continually propel each other higher into, or towards, the air; hence are produced thoſe uneven, hairy, and oblong little parts.

The nature of wax ſhould have been more accurately inveſtigated, in order to diſcover whether any fattiſh or inflammable matter be orginally mixed therewith out of the body of the Bee, which may be eaſily ſhewn from the ſtructure of the adjacent parts: for the ſecretions of the body are very wonderful; here fat, there oil; in one place gall, in another inſipid humours; on one ſide an aqueous or watry, and on the other, a clammy and glutinous ſubſtance; in one place volatile ſalts of an ill taſte, and in another ſweet, aromatic, and oily volatile ſalts. Of this laſt ſort is civet, wherewith if paper be daubed it bears writing on it; and by this teſt we moſt certainly diſcover whether civet be genuine. But theſe reſearches would take up great time and very great labour, for there is not on every occaſion a free admittance to all the ſecrets of nature; and the incomprehenſible weakneſs of our ſtrength is confined in every ſtep within its ſtated limits and narrow bounds.

I paſs now to the comb, or the cells and tubes of the Bees, which they form and conſtruct with wax, then fill with honey, and again cloſe up with wax; hence the comb properly ſignifies wax formed into cells and filled with honey. I ſhall firſt treat of the cells of the working Bees, then of thoſe of the males, and laſtly, thoſe of the females. All the cells of the working Bees are hexagonal both above and below, but the angles of the upper part are equal among themſelves; that is, they are equally wide, whereas in the lower part the angles are unequal; for three of them, in that part, are ſunk deeper than than the other three; the reaſon of which is, becauſe every cell, if it be a regular edifice, is built on the foundations of three other cells. Since therefore the foundation of the Bees cells tend obliquely downwards, like a triangle, therefore two angles make only one deſcending oblique angle: and conſequently the internal baſe of the cells conſtantly tends obliquely downwards, and is divided into three diſtinct parts, each of which anſwers to the two ſides of the hexagonal circumference of the cell. The three angles juſt mentioned are commonly right angles; and when they are pierced with a needle, that is, if every angle of the foundation be perforated, ſo that each cell is pervious by three apertures or holes, then thoſe three apertures penetrate on the other part into three diſtinct cells. It appears moſt evident from this palpable argument, that a cell is founded always upon three other cells, and therefore has a common diviſion with them; for none of the cells is circumſcribed by any limits or partitions peculiar to it alone, ſince all things are common between the Bees as between brothers. If the edifice be irregular it ſometimes happens that one angle of a cell reſts, or is ſupported on a fourth cell: this does not happen frequently, though I have lately obſerved it in a work that was pretty regularly built.

The foundation of the cells is placed in the middle, and the cells on every ſide reſt on this foundation, which is commonly like a wall, perpendicularly extended from the upper towards the lower parts; and then on each ſide againſt this kind of wall are placed cells lying obliquely on their ſides. Suppoſe ſome empty ale or beer glaſſes to be piled upon each other againſt the ſide of a thin wall, and you will in ſome meaſure underſtand the diſpoſition of theſe little cells: ſix, eight, or more ſuch walls, furniſhed with cells, are ſometimes found in one hive, and they are always placed at ſuch a diſtance from each other, as to afford the Bees an eaſy paſſage between them. But, leſt theſe combs ſhould fall down when they are full of honey, the Bee-keepers fix little ſticks in the hives when they are empty, about which the Bees form their works of wax.

All theſe cells, as well as their foundation, are formed of a continuous, but not contiguous, matter, ſo that all things are continued, nor can the cells be ſeparated from each other by any artifice, but by breaking or cutting them, whatever ſome might have erroneouſly imagined, thinking that every Bee built its own reſpective cell. Of this matter we ſhall treat hereafter more at large in its proper place.

If the whole edifice be regular, then five of theſe little cells make exactly an inch, and fifty-five an Holland foot. Hence a French gentleman obſerving this, and imagining that theſe cells were conſtantly built after the ſame rule, thought he had diſcovered an everlaſting meaſure, which as it could never be deſtroyed might be introduced among all nations. This invention would be certainly confirmed, and its importance proved, if theſe little cells were always ſo exactly conſtructed, and the combs in all nations were conſtantly of the ſame magnitude; but with us the combs are not always ſo exactly regular as is commonly believed, though if we view the cells only curſorily, they do not ſeem to differ a hairs breadth in meaſure from each other. If any one compares them accurately one with another, he will ſometimes find them irregular; eſpecially when they are made by the Bees in ſuch a manner, as to fit them only for receiving the honey. The three parts of the foundation of the cells that tend obliquely downwards are uſually ſquare, but they are ſometimes oblong, and ſometimes of a rhomboidal figure; nay, I have obſerved that ſome of them were longer or ſhorter than others, and were alſo ſometimes narrower and ſometimes broader. Nor does every little cell reſt conſtantly on three cells, but ſometimes on two and an half, and ſometimes on three, and a part of the fourth. Moreover, theſe entire cells are ſometimes twice or thrice as long as uſual, and they are likewiſe ſometimes crooked or ſinuated, altogether like the cells of Hornets, which are commonly ſomewhat crooked, becauſe they are extended little beyond their foundation or center. Bees never build in this manner, unleſs when very great plenty of honey offers to be gathered, for then I have ſeen cells full of honey, ſealed up and ſuſpended like large lumps of earth in the hive.

In regard to the cells of the female Bees, erroneouſly called the kings, and the parts where they are joined to others, conſiderable irregularities frequently occur; though all of them viewed curſorily may ſeem alſo to be very regular.

We muſt further obſerve, that the Bees never build their cells ſeparately, that is, ſo as to perfect one before they begin another; they always enter upon building a great number of cells together with their foundation at one and the ſame time. In the beginning of the work, they lay that hollow triangular foundation which bends down obliquely, and terminates or gathers itſelf in acutely; then they conſtruct the lower and hexagonal or unequal ſides: ſo that in one and the ſame hive, may be ſeen at the ſame time, the beginning of the foundation, and the rudiments of the hexagonal diviſions of the cell on one ſide, and the ſame cell on the other ſide, raiſed higher on the ſame foundation, and other ſides again but juſt begun and riſing. Moreover, in regard to this building of the cells, a very wonderful and artificial direction or management of the Bees is to be mentioned. This they put in practice when the riſing hexagonal ſides of the cells are very thin and weak; and when they have a mind to leave ſuch cells imperfect for ſome time, which is the caſe when the female, in order to lay her eggs, goes to another part of the hive; as I ſhall explain more at large hereafter. When this happens, the Bees firſt fortify all the edges or borders of the hexagonal and imperfect ſides, leſt they ſhould be broke or bent in the mean time, which might eaſily happen by the frequent running of the Bees over them. They therefore furniſh the ſides of the imperfect cells with a margin or border glued thereon in the upper part, and prepared of a thicker and more ſolid ſort of wax, and they put this waxen border on the extreme circumference of the hexagonal ſides, ſo that, by this means, the hexagonal figure of the cells, which was beginning regularly to ſhew itſelf, is again in a manner obſcured. They ſometimes alſo border the cells that are finiſhed and perfected; from which this further good ariſes, that when ſuch cell is to be afterwards cloſed up, there is no neceſſity for ſo much time or wax. The Bees, therefore, uſe the ſame precaution in reſpect to their imperfect cells, as if any perſon ſhould cover the extreme edges or borders of the tender and broken ſides of a glaſs cup with ſealing wax, in order to ſtrengthen it and handle it with leſs danger.

The cells of the males are one third leſs than thoſe of the common Bees, but they are made in the ſame manner; and they are commonly placed in the loweſt part of the comb; for they are built after all the other cells are finiſhed; ſometimes there are three hundred, four hundred, or even more of theſe in one hive, but often fewer. The Bee-keepers attribute the ſmaller number of theſe cells to the dryneſs of the year, and the greater number to plenty of rain in the air: hence they ſay that a great number of males in a hive is a ſign of a very wet year. But theſe are mere fancies, ariſing from a notion, that the Bees, when the ſeaſons are dry, are intent only on gathering honey; and, on the contrary, in wet ſeaſons, mind principally generation, but though thoſe perſons have kept Bees fifty years, they underſtand nothing of the buſineſs of their generation, nor do they know what ſort of a creature the breeding Bee is, for they call it the male. I would not have it underſtood here, that the number of the cells which I exhibit is abſolute and exact, for I have made the calculation in general from their numbers; nor have I even, very accurately, counted them all.

There are ſometimes thirty female cells found in one hive few are perfect, but a great many unfiniſhed; their ſtructure is not regular, but they are for the moſt part oblong, and roundiſh, and ſomewhat pear-ſhaped: ſometimes they are conſiderably ſtraighter, and have a leſs ſwelling than a pear, but others again are ſomewhat more globular. Their external ſurface is unequal, rough, and marked or diſtinguiſhed by little holes and exuberant prominences, and is conformed only to the figure of the comb. The inſide of the cells of the common Bees has a very ſmooth and poliſhed ſurface; but theſe differ again from them in that they form a cavity like that of a bottle or a ſcooped pear; from this ſhape, they are very capacious, and ſurpaſs in bigneſs the cells of the common, and thoſe of the male Bees. The females therefore have a much larger ſpace than the other Bees to turn themſelves more freely in their cells; the reaſon of this difference I ſhall explain in its proper place. The cells of theſe females are uſually, nay, almoſt always ſituated near the borders and prominent extremities and edges of the hive, and are ſeldom found placed in the center or in the middle between the other cells; all theſe particularities tend to certain uſeful ends, and therefore the laws of making them were not impreſſed on theſe little creatures without deſign, by the moſt wiſe Creator. I ſhall now endeavour to illuſtrate with figures what I have hitherto related. The firſt figure, Tab. XXIII. exhibits a regular hive of common Bees, as it preſents its hexagonal and regular ſections to the eye, when viewed in the upper ſide; nor could it be poſſible to delineate theſe ſections, without the aſſiſtance of ſome new-invented lines; which being allowed, it is then eaſy to deſcribe the ſections, for which reaſon I here delineate ſome of theſe lines. The ſecond figure under the letter *a* exhibits three ſingle cells of the common Bees, broken from the reſt of the comb, with their triangular baſis running down obliquely. The letter *b* repreſents one cell only, entirely ſeparated from all the reſt; in this, beſides the obliquely deſcending triangular foundation *c*, are likewiſe ſeen under the letters *d d* two unequal or uneven parts or productions of the hexagonal ſides. Now if you ſuppoſe this cell *b* placed on the cells *a*; it will follow that its three oblique angles agree with the three angles of theſe cells, and are ſupported by them. The third figure ſhews a little cell cut through the middle, in which may be ſeen the triangular foundation and the ſix ſides; one of them is formed out of the oblique angles, as appears at the letters *b b*. Moreover, fig. IV. ſhews fifteen little cells, cut on each ſide, between which a part of the triangular foundation, which runs obliquely, is plainly ſeen in each cell. It is here alſo evident in what manner theſe cells *a b* are built upon the ſame foundation *d* whereon the cells of the other ſide reſt *c*. Again, the letter *d* very exactly repreſents the the triangular foundation, which runs in obliquely, as it really is ſeen in nature. The ſame is likewiſe delineated under the letter *g* between the cells of each ſide, but it is here divided by a ſection which paſſes through the two angles. The letters *f f f f* exhibit two long ſides of the cells; but the letters *e e e e* the two ſhorter ſides. For every cell, as I have obſerved before, has in its lower part three longer and three ſhorter diverging ſides, which in the upper part are of an equal length.

The fifth figure which follows next, repreſents ſome cells of the males, which are a third part larger than thoſe of the common Bees. In order to render this difference the more conſpicuous, I have delineated them ſomewhat larger than they really are. Between each of theſe cells is ſeen that triangular obliquely diverging baſis, each of whoſe angles agrees with the deſcending ſides of the cell. But I have not delineated the cells that are built on one ſide of this baſis, becauſe it did not ſeem neceſſary. To the upper part of theſe cells is obſerved to adhere a pear-ſhaped lodgement of the nature of a cell: this is deſigned for the females. It is irregular in the upper part, and is adorned as it were with depreſſions or little holes, here and there impreſſed on the wax.

If the cells hitherto deſcribed have been lately finiſhed, and have not yet any honey, or Bee-bread, or eggs, or Worms, or riper iſſue in them, in that caſe their ſubſtance is genuine virgin wax, which has no foulneſs among it, and may be all melted. On the contrary, the wax that is whitened by bleaching, and which is ſold in the ſhops by the title of virgin wax, has nothing but the name, ſince it loſes a great part of its ſtrength by being adulterated with powdered talc, and bleached in the ſun.

The honey likewiſe which is collected pure in theſe virgin cells, and flows again out of them ſpontaneouſly and without preſſure, is pure virgin honey, better and more perfect than any other honey whatſoever.

It is ſeldom obſerved, as the Bee-keepers ſay, that the cell of a female is joined to the cells of the males: but experience has taught me the contrary of this, having in my poſſeſſion at this time a ſpecimen, in which the cell of a female is built adjoining to thoſe of the males. As many others, ſo this error had its origin from that imagined regal dignity, which they have wrongly aſcribed to the female; for from this the notion was eſtabliſhed, that the favour of coming ſo near to the king was too great to be granted to the drone. But the acceſs of the drone to the queen is ſo neceſſary, that ſhe cannot be impregnated unleſs ſhe be firſt familiar with, and aſſiſted by the ſpermatic virtue of the drone, who is the true and only male.

All the families of the tripple kind of Bees would therefore periſh, unleſs there were this intercourſe: ſince what is erroneouſly called the drone is the real male Bee, and therefore does not claim to himſelf a lower place in the hive than the queen herſelf the female parent. To this may be added, that the drone is more tractable and mild in its conduct and diſpoſition than the two other kinds of Bees, for it employs its whole time in the labour of love and proceſs of generation; nor is it armed with a ſting as the others, nor to be dreaded for its miſchievous qualities.

To conclude, how do the Bees make theſe cells? and by what art do they build them in ſo ſtupendous a manner, ſo regularly, that they cannot be ſimply or plainly delineated but with great labour, and by the intervention of ſome new ſpecies of lines, and not even then without committing great errors? He ſurely who ſees all things, and promotes the generation of the wild herds; He, and He only knows this. I ſhould think this matter may be probably inveſtigated and brought to light, if any one would labour at it with the needful diligence and attention: nay, I am confident, that I myſelf could ſucceed in the inquiry, if I had an opportunity of feeding the Bees for ſix months, and enjoying the peaceful bleſſing of a country life. However this matter may be, I confeſs myſelf now as ignorant thereof as all others. However, I firmly believe, that the Bees make uſe chiefly of their teeth for this buſineſs: hence the common Bees which alone build all the cells of the hive, have much larger teeth than either the females or the males; nay, the males have ſtill ſmaller teeth than the females, and probably the males have them for no other purpoſes, but to bite open their little cells when they are come to full maturity therein, or to open thoſe filled with honey when they want to eat. Whether the legs of the Bees, between the claws of which a ſingular kind of ſoft matter is produced in knobs, contribute in any meaſure to perfect and elaborate the wax, I am likewiſe hitherto at a loſs to diſcover. Yet I ſcarce doubt, but that humour which paſſes through the ſting of the Bees alſo conduces ſomewhat to prepare the wax, and fit it for building the cells. It would be worth while to examine all theſe points more accurately. It is very wonderful to ſee how inſtantaneouſly the Bees, when they are offended, emit all their poiſon through their ſting. This poiſon may be ſeen at the end of the ſting, and is like a little drop of cryſtal. But if this little drop, while ſtill adhering to the extremity of the ſting, be ſuffered to grow dry, it then remains pellucid and concretes, and is like the boiled cryſtaline lens of a fiſh's eye; it is therefore very eaſily condenſed by the circumambient air.

Since I am treating of the wonderful induſtry of this little creature, which, however, is not more remarkable than that which all other inſects ſhew, according to their reſpective diſpoſitions, I cannot help here mentioning, to the glory of the great Architect and Artiſt, he wonderful works of a certain inſect, the external form of which has been very clearly deſcribed by Goedaert in the firſt part of his Nat. Metamor. Exper. x. This inſect is the nocturnal Butterfly or Moth, which glues its eggs ſo ſtrongly and firmly in the form of a circle to the branches of trees, that they make an impreſſion upon the bark, and often prevent the increaſe of the branches. What occurs here very extraordinary is, that the eggs of this inſect are formed in the ſame manner as thoſe hewn ſtones, which are adapted to build the arches and roofs of houſes, and have one ſide narrow and the other broad, that they may be the more exactly joined together, and conſtitute one firm arched form. They may likewiſe be compared to the lines of a circle drawn from the center to the circumference, which are the nearer to each other the more they approach to the center, and diverge towards the circumference. In this manner has the ſupreme Architect, the Almighty, formed theſe eggs, which are artificially and in a ſpiral curvature ſo ſtrongly glued together, and affixed to the tender branches of trees, by this inſect, who for that purpoſe walks many times about the branches, that they cannot be looſened by rain, or any other liquid that I have yet applied. Out of theſe eggs, which, according to the accuſtomed order of nature, by which the egg of the Butterfly is only a Worm incloſed in its ſhell or caſe, ſhould have produced Worms or Catterpillars, I have ſeen Flies wonderfully ſmall, immediately iſſuing in their perfect ſtate. This obſervation ſeems to me to be the moſt extraordinary of all in this part of natural hiſtory; and therefore, I hope I ſhall, with the aſſiſtance of God, at ſome time write a particular treatiſe thereon. I have here given the hiſtory of this ring of eggs, becauſe it will be hereafter made uſe of in its proper place, and produced for the ſake of illuſtration.

I ſhould never conclude this part of the work, if I attempted to exhibit the deſcription, induſtry and art of theſe creatures, or to give but a rude delineation thereof. I cannot help mentioning here, the ſingular ſkill and addreſs, not indeed of an inſect, but of a ſanguiferous animal, that is, of a young houſe Dog which I keep. This creature is afflicted with a running ulcer or fiſtula, which is ſituated ſo high at the lower part of the eye, that his tongue cannot reach thither to lick it. Therefore this creature follows a remedy happily invented and diſcovered, as it were, by reaſon, and applies it to this evil; it firſt wets its foot with its ſpittle, and then rubs the moiſture with wonderful dexterity over the ulcer, endeavouring to cure it in this manner: nay, when the mouth or orifice of the fiſtula has at any time cloſed, the creature rubs it ſo long with its foot, that the ſurface becomes very red like blood.

To return to the Bees. They are about the beginning of Auguſt inflamed with ſo much hatred againſt the males, that they unmercifully and for no crime kill them: whereas, at the end of May, and ſometimes ſooner, they build houſes for them, carefully nouriſh them, bring them there, and take all poſſible care of them. I ſhall afterwards endeavour to explain, in its proper place, the reaſon of their changing this love into hatred; ſince I have reſolved to compoſe this hiſtory to the glory of God alone, without any other view.

Before I proceed further in this reſearch, I ſhall deſcribe the male, female, and common Bees together, and compare them one with another as to their external parts, beginning with the common Bees, which are moſt eaſy and familiar to be known, and which have been at one time or other ſeen and handled by every perſon. In the common Bees as well as, in all the other kinds, we are principally to obſerve the twelve diviſions or rings of their body; five of them are placed about the head and thorax, and that ſlender and delicate part which connects the belly with the thorax, and the other ſeven in the body.

The head of the common Bee is oblong, ſomewhat rounded above and ſharp below. The head of the male is throughout of a rounded form, and that of the female Bee is oblong.

The eyes in the head of the common Bees are of an oval or lunated figure. They are of the ſame form in the males alſo, but they are two thirds larger than thoſe of the common Bees: this deſerves to be well regarded. There is ſomething like this in the Ephemerus or Day-Fly; the eyes of the female Bees are ſomewhat larger alſo than thoſe of the common Bees. The eyes of theſe three ſpecies of Bees are covered or ſurrounded with briſtly hairs, and are ſeparated from each other by a number of the like hairs. Theſe hairs are twice, nay thrice as long as the diameter of the little ſpheres into which the eyes are divided. The ſame thing is likewiſe obſerved in other inſects. In the upper part of the head ſomewhat higher than where the hairs juſt now mentioned are ſituated, we likewiſe diſcover many ſmall feather-like hairs in the common Bees, and nearly in the ſame part alſo, three peculiar little eyes. Theſe feather-like hairs are not found in the males, for their eyes are extended ſo far in that part that they touch each other. And this is alſo the reaſon, that three of their eyes in particular are ſituated much lower than they are in the common Bees, and juſt above the horns. The female agrees with the common or working Bees in theſe particulars, that her eyes are ſeparated in the ſame manner from each other, and there are three peculiar little eyes likewiſe placed in her head in the ſame manner.

All Bees have two horns or antennæ. Thoſe in the working Bees have only five joints, but thoſe of the males have eleven, and thoſe of the females the ſame number. The firſt joint, where the horns riſe from the head, is oblong in the common Bees, but in the males it is ſomewhat ſhorter, and it is again ſomewhat longer in the females. In the common Bees there is a ſmall quantity of ſhort hair, under the horns, but the hair under the horns of the males is more in quantity, longer and feathery; in the females again it is obſerved to be like that of the common Bees.

Above the teeth in the common Bees is ſeen a remarkable kind of horny or bony lip, which is not ſo obvious in the males; but it is found in the females in the ſame manner as it is in the working Bees.

The common Bees have two long teeth, the males have very ſhort and ſmall ones; thoſe of the females are ſomewhat larger than thoſe of the male Bees, ſo that they hold as it were the middle place.

The proboſcis is very long in the common Bees; in the males it is ſhorter by one half. I have hitherto miſſed the opportunities of examining it in the females.

The thorax is roundiſh in all the kinds of Bees, and in the upper ſide of the hinder part it is provided with a ſomewhat prominent border or margin. In the common Bees this thorax is covered with thin feather-like hairs: in the males theſe hairs are more cloſe ſet together, and thicker, but not quite as long; they are alſo of a more gray colour than in the common Bees and females. The females have a leſs number of theſe hairs than either.

All the kinds of Bees have four wings. Theſe are longer and broader in the male than in the common Bees; but in the females, though the wings be longer, and probably longer than even thoſe of the common Bees, yet they ſeem ſhorter, becauſe the lower part of the female's body is vaſtly larger and longer than either of the others, in order to give room for the eggs.

Each of the three kinds of Bees makes a noiſe by the motion of its wings, which is increaſed by the internal air propelled out of their bodies through the air tubes at the ſame time; for ſome of theſe pipes open with wide apertures under the wings. Certain cavities alſo, fit for receiving and vibrating the air, and formed under and between the wings, contribute to this. Nor muſt the ſhoulder-blades be excluded from their ſhare in this muſick, they being placed juſt above the wings, joined to the thorax, and having under their breadth the gaping orifices of ſeveral air-pipes. It is thus the motion of the wings, with the aſſiſtance of all theſe parts, and by the force of the propelled air, make the humming noiſe peculiar to that inſect.

All Bees are provided with ſix legs, each of which conſiſts of nine joints; the thigh has three of theſe, the leg two, and the feet four. In the common Bees the hinder legs are broader than the fore ones; but this difference is not ſo remarkable in the males or females. On the fifth and broadeſt joint of the hinder legs, which is the firſt joint beyond the thigh, the common Bees on each ſide carry wax, or the Bee-bread, collecting it into a heap at the outmoſt ſide of the leg, for there the leg is not ſo hairy as on the inner ſide. In that part alſo the lower, and near the next joint of the leg, are placed ſome briſtly and almoſt horny hairs which are neither found in the males, nor are ſo diſtinctly viſible in the females. The third or laſt joint of the leg is longer than the two former, but the two next joints are ſmooth and ſomewhat broad, and thoſe are cloſely covered on the inſide with fine feather-like hairs. The leaſt of the four joints of the legs is alſo ſomewhat broader than the three former; and in this part are inſerted ſtrong muſcles, deſigned for moving the claws of the feet.

The feet are armed with two larger and two ſomewhat ſmaller claws; but the ſmaller are as it were jointed or articulated into the larger.

Between the claws of every foot is ſeen a very ſoft matter, of a membranous texture, from which, when wounded, there flows a clear liquor. The Bees in walking can at pleaſure turn out this tender part of the foot, and therefore I ſhould think, that having drawn back the claws of their feet, like Cats when they are playing, they are able in this manner to run over their young brood, or over the new formed wax, without doing the leaſt hurt to either.

The four hinder legs are placed at the lower and hinder part of the thorax, the two others are fixed to the fore part. And this is the reaſon why theſe two fore legs, when you take the head of the Bees from the body, are ſeparated together with that, and remain with it, being fixed to it as it were by a kind of ligament.

In the common Bees the ſeven laſt rings of the abdomen are of a blackiſh brown: in the males they are yellowiſh, as they are likewiſe in the females, but more eſpecially about the lower part, for there the rings of the abdomen are almoſt all yellow; and this is the reaſon the queen Bee is ſaid to be of a golden colour.

The ſting, which in the common Bee is protended ſtraight from the body, is wholly wanting in the males, and in the females it is bent *.

The common Bee is little more than of half the bigneſs of the male, the female is alſo ſmaller than the male or drone, but it has a much ſlenderer and longer body, in which, as well as in bulk, it conſiderably exceeds the common or working Bees.

The colour of the common Bee approaches to an obſcure yellow; the males are ſomewhat grayer, and the body of the females is more of a gold colour.

The parts of the Bees hitherto mentioned are almoſt all hairy or ſhaggy, and when they are viewed with a microſcope, we obſerve that thoſe hairs are in reality very beautiful feathers, as is ſhewn in Tab. XVII. fig. VIII. This ſhall be explained afterwards more at large.

The common Bees may be conſidered as natural eunuchs as it were, belonging to neither ſex; though, however, with reſpect to their ſtructure and diſpoſition, they approach nearer to the female than to the male ſex. The males have very conſpicuous and large genital organs. The females have an ovary, and in it an infinite number of eggs, as I ſhall deſcribe in its place. But the common Bees are not furniſhed with either maſculine or feminine genital parts.

As to the internal parts of the Bees, the three ſpecies have ſome common to each of them, and others peculiar to each. The internal parts common to all, are in the head, the brain conſiſting of the cerebrum and cerebellum; the beginning and globular dilations of the ſpinal marrow, which thence pervades the whole body from one extreme to the other; and laſtly, the nerves iſſuing as well out of the ſubſtance of the marrow, as from its dilated little knots; all which I have deſcribed and delineated in the diſſection of the male Bee. The internal ſtructure of the eye is alſo in general the ſame in the three kinds; the tunica uvea, the inverted pear-ſhaped fibres, and the cortical ſubſtance which performs the office of an optic nerve, are very little different in

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* The beſt way of viewing the ſting of the Bee by the microſcope, is to hold the creature faſt by the thorax with a pair of knippers, and it will thus thruſt out the ſting, often, in its fury. This ſhould be cut off with a fine pair of ſciſſors, and it may thus be preſerved entire between two ſlips of iſinglaſs.

Another way is, to make the Bee ſting a thick leather glove. This will be eaſily obtained, by catching one with ſuch a glove upon the hand. The Bee will ſtrike with its ſting, and it muſt be immediately frighted off. By this means it leaves its ſting in the glove, which may be picked out and viewed.

either. This I have likewiſe exhibited in the figures of the male Bee. In reſpect to the muſcles and nerves of the proboſcis and jaws there is no difference. In the thorax each of the three kinds ſhews the muſcles of the wings and legs, as alſo many pulmonary tubes and ſome fat; ſome of this is likewiſe found in the head. In the body is ſeen the continuation of the gullet, which deſcends thither from the mouth through the thorax: we may likewiſe perceive there the ſtomach, the ſmall and great guts, and ſome valves; we diſtinguiſh alſo ſix peculiar glands, placed between the inteſtines, as I have deſcribed in figures in the common Bee. The lungs are alſo very particularly ſeen in the body, as are alſo their dilated bladders and branching pulmonary tubes; all which I have likewiſe delineated in the common Bee. The heart, together with its dilations and the pulmonary tubes which run all over its ſurface, is in great part alſo placed in the abdomen, though it may in part likewiſe be ſeen in the breaſt and neck, as I have delineated in the female. In fine, a great quantity of fat is alſo found there, and we perceive ſome membranes and muſcular fibres ſituated under the rings of the abdomen, and deſigned for moving thoſe parts; as alſo ſome ſmall pulmonary tubes which paſs through thoſe parts. I have repreſented all theſe in the female Bee, and they are common alſo to all the three kinds.

The internal parts peculiar to each kind, are, firſt, the genital organs of the male; that is, the internal horny little bone belonging to thoſe parts, the penis, the teſticles, the vaſa deferentia, and their dilatations, the ſeminal veſicles, a peculiar ſmall part that is cut into five diviſions a pear-ſhaped little part, and two appendages which terminate in a point. In the female are likewiſe ſeen the parts that ſerve for generation; the ovary, the oviducts with their diviſions, the eggs, the pulmonary tubes appropriated to them, the two trunks of the womb, through which the eggs are conveyed, the neck of the womb, and the bag containing a glutinous matter.

The following parts are peculiar in the common Bee; the ſting and its poiſonous bag, with its tubes iſſuing as well out of the fore as hinder part thereof; the caſe of the ſting, and alſo its ſupports, cartilages and muſcles, none of which parts are found in the male.

By this general and particular compariſon of the three kinds of Bees with each other, it is ſeen that the common working Bees approach nearer to the nature and diſpoſition of the females than of the males; ſince the external and internal parts in general, as will be made plain hereafter, agree in both: excepting only that the common Bees have no ovary, and therefore, like women who have lived virgins till they are paſt child-bearing, ſerve only the purpoſe of labour in the oeconomy of the whole body. Theſe are thus by nature rendered incapable of doing any other buſineſs but that of nouriſhing and educating the young offspring, building the little cells for the Worms of the females progeny, and providing food for themſelves and theſe their brethren, that they may have wherewithal to live in the winter ſeaſon, and at all times in rainy and ſtormy weather. The female, on the contrary, and the males do nothing of all this; for the female lives in the hive for no other purpoſe, but to depoſit, as occaſion offers, her eggs in the cells: and it is the buſineſs of the males to impregnate thoſe eggs before they are caſt out, whilſt they ſtill lie in the ovary of the female: this they do during one whole year, that is in the time between the two ſwarms.

For theſe reaſons the common labouring Bees maintain the males and females with plenty of honey. But as ſoon as this ſeaſon of generation is over, and the males having performed their duty, the labouring Bees kill them as being entirely uſeleſs and unable to do any more good, though they might have lived longer. I could wiſh indeed that I had an opportunity of inveſtigating this matter more exactly, and trying whether or not I could keep a whole hive, containing only males and one female for an entire year. This is indeed much to be doubted, for experience ſhews that many Bees die ſpontaneouſly, and without any violence, about the time of this univerſal ſlaughter. Sometimes when the female is unfruitful, or of a bad conſtitution, or when there is too ſmall a number of Bees, or there are two females in the hive, the Bee-keepers ſay that the males are ſometimes found to live till the winter is far advanced: but they never continue to the beginning of ſpring; which, whether it is to be attributed to the natural ſhortneſs of their life, or whether they are then deſtroyed by the other Bees, is not hitherto ſufficiently known.

From one female, which is the only one of that ſex in the whole hive, are produced all the three kinds of Bees, in nearly the following proportion, ten, twelve or fourteen females, ſome thouſands of the labouring Bees, and laſtly ſome hundred males: more or fewer are occaſionally found in the hives of each kind. I have deſcribed another ſpecies of inſects in my general hiſtory of the inſect tribe: the males of which is winged, but the female has no wings; which is alſo a wonderful kind of wedlock. The omnipotent God has been pleaſed to join ſeveral males to one female in this family of the Bees; whereas on the contrary among domeſtick fowls, and in many other inſtances, one male is ſufficient for a great many females. This is likewiſe the caſe in many of the inſect kind; that is, that one male ſhould impregnate many females. This is obſerved with reſpect to the males of Silk-worms. But the female among the Bees is impregnated in a peculiar manner, merely by odoriferous effluvia.

Six days after the time of ſwarming, the young female Bee newly got out of her cell, depoſites her eggs in the new-built cells of the combs: the labouring Bees which attend the female during the ſwarming, begin immediately at the very time when the hive is preſented to them, or as ſoon as they have choſen a convenient place for themſelves for, they have no guide or director, to make their combs; and the female doing her office as haſtily, the freſh combs are in a very ſhort time filled with her eggs: the female drops one egg into each cell; and what deſerves great attention is, the female is ſo expeditious in this work, that ſhe does not regard whether the cells be only juſt begun or perfected, or whether they have been built ſome time. It is enough for her the obliquely deverging triangular foundation be laid; there ſhe immediately drops in her eggs, and the labouring Bees, which, for this purpoſe continually attend the female at that time wherever ſhe goes, afterwards further perfect the unfiniſhed cells. To execute this work, they are ſtimulated with an extraordinary ſolicitude, love and induſtry, impreſſed on them by the ſupreme Creator towards thoſe tender eggs, which are to afford the offspring of the Bees, as towards their natural brethren. We muſt particularly obſerve, that the earneſtneſs wherewith they undertake the care of bringing them up, is not extinguiſhed in them; though the female be taken from among them, as I ſhall explain in another place, where I ſhall alſo demonſtrate that the whole ſociety of Bees regard not any thing elſe but only propagation and rearing of their young; nor is there any other government whatſoever, nor any election, or any politic or œconomical diſcipline or order among them. The moſt wiſe, and all and every where adorable God, has implanted ſuch ingenuity and wiſdom in theſe inſects, that they can bring up their iſſue and prepare habitations for them, which the ſame moſt powerful Creator has not been pleaſed to give to other creatures; whereof, among the reſt, the Silkworms may be an inſtance; and it may be evidently proved that the cohabitation of Bees has no other end but to perpetuate their ſpecies; and thus, by the help of an exact order of production, to perpetuate their continuance.

From theſe conſiderations it therefore follows, that among Bees there is no wiſer regulation than among domeſtic fowls; for they have their natural deſire to ſit; they make neſts, and nouriſh their young, being compelled thereto by ſuch laws as they cannot avoid nor ſuppreſs by any rational principle; becauſe they are impreſſed on them by the eternal law of natures. Theſe little inſects are under as great neceſſity to perform all theſe actions, as the winter is to follow the ſummer. The only difference among the ſeveral kinds is, that ſome execute theſe functions in a manner more convenient, more orderly, and more agreeable to reaſon than others. This appears chiefly in the Bees, and hence there is no authority for the prevalent and common opinion that the government of Bees is carried on with the ſcepter of prudence and judgment, under law, and with rewards and puniſhments: for in truth all that order which we ſo much, and not without reaſon admire, is impelled by nature, and is only deſigned for the propagation of their ſpecies. But we muſt not for this reaſon deny, that the Bees in performing their work, diſcover and exert the appearances of wiſdom and the moſt prudent counſel; for the ſacred writings teach us, that God has deprived thoſe creatures of reaſon, to whom he has not thought proper to commit the care of nouriſhing their young. This office is not granted to the Bees only, but is given to the Hornets, Waſps, to humble Bees, and to Ants; which, as well as all other inſects, would doubtleſs have periſhed as ſoon as they had laid their eggs, unleſs they had the care of educating their ſtock committed to them: for which reaſon it is neceſſary they ſhould live ſomewhat longer.

Behold! God ſhews himſelf ſo ſtupendous in theſe ſmall creatures, that I ſhould almoſt preſume to affirm that the ineffable miracles of God are ſealed up as it were in the hiſtory of theſe inſects. But theſe ſeals are at length opened, when we diligently peruſe and often read over the book of nature, and natural theology, wherein the inviſible things of God are explained to the eyes; then treaſures of miracles which no tongue can worthily deſcribe preſent themſelves, and the unſeen Creator becomes ſo manifeſt in theſe his ſmalleſt creatures, that the experiments I have made on them are to me the ſtrongeſt and moſt irrefragable arguments, by which I conſtantly maintain his eternal Godhead and providence againſt all oppoſition. Atheiſts allow only a fictitious putrefaction, and a metamorphoſis, inveſted in their own brain, and the fortuitous conflux of atoms; by the help of which they aſſert, indeed with very weak and ſorry arguments, that theſe creatures are produced; whereas, on the contrary, the limbs and parts of theſe minute creatures are conſtructed with greater art than thoſe of the largeſt animals. The Louſe or Mite itſelf proves a deity, and the majeſty of God is as ſtupendous and worthy of admiration in the minuteneſs and ſmallneſs of that creature, as in the unwieldy ſtrong Leviathan: thoſe who view him in theſe his works cannot but reverence and adore him. God himſelf ſpeaks to man in this glorious manner in the magnificence of his works. And in what other thing can he be known but in his creatures only? Having named the Louſe, I ſhall here add that the little part of that creature which is ſo elegantly moved up and down in the body, is only the ſtomach and the inteſtines annexed thereto, which produce ſuch an effect by the force of their periſtaltic motion.

The eggs which are laid by the female Bee in every little cell of the comb, are oblong, ſomewhat bent, and thicker on one ſide than on the other; but they are throughout tranſparent, limpid, and bright, and are full it ſeems with a watery matter, and faſtened by a very ſmall extremity to the wax. On the other extremity, therefore, the egg ſtands upright in its cell, and it touches not the wax except at one end. After what manner theſe eggs are ſo firmly faſtened to the wax, I ſhall explain in its proper place. We muſt only obſerve here, that almoſt all ſpecies of inſects, when they are about to bring forth young, affix their eggs by ſome means in that firm manner; whereof I can indeed exhibit many very uncommon inſtances. Among others, I have eggs of inſects diſpoſed in a ring, which are thus glued round the branches of trees; I have ſome other eggs hidden as it were in froth: others again which are covered very thick with hair, and ſo on without end. As to thoſe eggs that are covered or beſet with hairs, we muſt obſerve that Butterflies, which ſtrengthen their eggs with ſuch an integument, have thoſe hairs originally ſituated in the circumference of the hinder part of their body: and therefore when they bring forth or lay an egg, ſome of thoſe hairs naturally ſtick to it, becauſe it is covered over with a viſcous moiſture; and thus all the eggs become at length ſhaggy: the creatures themſelves become bald by this in the part juſt mentiond, which is a very remarkable obſervation. Thus we may learn ſomething worthy of attention from every part of God's works: for that Almighty power goes through all lands and tracts of the ſea as well as the higheſt heavens.

When the eggs of the Bee have been hatched in the comb, then in the bottom of the waxen cell there is obſerved a kind of web of a membranaceous texture, to which the egg afterwards adheres, or is firmly faſtened.

But the egg is not always fixed in the ſame place, that is, in the bottom of the cell; ſometimes it adheres ſomewhat higher and again ſomewhat deeper, according as the obliquely diverging cavity of the cell itſelf is variouſly conſtituted, or according as the hinder part of the female's body, can be moſt eaſily thruſt into this cavity. However, the eggs are conſtantly placed on the obliquely deverging foundation of the cell, though they do not always ſtand perpendicularly upon it; but ſome more, ſome leſs obliquely: for the foundation always deſcends perpendicularly, though the angles are ſomewhat inflected.

If the egg of the Bee be viewed with a microſcope, it appears ſomewhat wrinkled: but thoſe wrinkles are regular, and are laid almoſt in the ſame order, as in the skin of Fiſh after the ſcales are off; which, the veſtiges of the ſcales being ſtill conſpicuous, are yet diſtinguiſhed in a regular manner. Something like this is alſo obſerved in the skin of Birds ſtript of their feathers.

I ſhould think that the hinder part of the encloſed Worm lies in the thicker extremity of the egg, and the fore part in the thiner extreme. This Worm in ſome days afterwards breaks open the membrane of the egg, and creeps out of it under the form of a crooked Worm, exceſſive tender, and without legs. But in this Worm the diviſions or annular inciſions of the body are immediately conſpicuous, nor does it ſtand erect as the egg did, but lies on the foundation of the cell: the natural figure of the eggs may be ſeen in Tab. XXIII. fig. XI. for there ſix eggs are delineated in their natural ſize: they ſtand erect and oblong, are very ſlender, but ſomewhat thicker in the upper part; as may be ſeen under the letter *a*, fig. XII. Under the letter *b* a microſcopic view of one of theſe eggs is exhibited, reſembling the skin of a Fiſh new ſcaled; in which one may ſtill ſee the joints, ſeams, or impreſſions where the ſcales had ſtuck. Further, I ſhew in fig. X. a little part of the comb, furniſhed with nineteen cells, nine of which are conſpicuous with their erect eggs; four others contain ſome tender new hatched Worms, which have caſt their skin a little before; and laſtly, the five other cells contain Worms ſomewhat larger and more grown. I have cut off theſe little cells at one half of their heighth, that their triangular foundation on which the eggs ſtand erect, and which ſupports the Worms, may be ſeen more diſtinctly.

But I ſhall proceed, and taking up again the interrupted diſcourſe on the Bee's eggs: obſerve, that they are, until the time of their being hatched, when a kind of very ſmall Worm creeps out of them, left without the care of other Bees, and without any kind of ſitting or incubation; though the contrary opinion has been hitherto eſtabliſhed, which appears to be likewiſe in ſome degree ſupported by experience. I ſhould think, at leaſt, that the Bees go often to viſit them, that they may know for certain whether or not the Worms are come out of them. But this they can likewiſe obſerve when they follow the female wherever ſhe goes. The little cell alſo, in which the egg is repoſited, remains often to be finiſhed afterwards; ſo that in this caſe they may eaſily know occaſionally whether the Worm has crept out of the egg or not. But as the internal parts of the hive are very dark in reſpect to our eyes, and the eggs with difficulty diſcovered in the bottom of the cell, I ſhould think it follows from thence that the Bees can ſee as well in the dark as in the light, which is likewiſe the caſe with many other inſects. The eyes of the Bees indeed ſeem much better accommodated for this purpoſe than thoſe of any other inſects whatſoever; as their ſtructure will afterwards demonſtrate. For the Bees do not ſee by force of collected rays, by which the image of the object is painted inwardly on the eye; as is the caſe to demonſtration in an Ox's and Man's eye, when the external coats to the uvea are firſt taken off: but the ſimple touching and reflection of the rays on the external ſurface of the eye, evidently performs the act of viſion in the Bee.

The incubation of the egg happens only by the heat of the external atmoſphere, and by the heat which all the Bees encloſed in the hive, produce by their perpetual motion; for that buſineſs is performed here in no other manner than as it is with reſpect to the eggs of Silkworms and other inſects, which are hatched by the natural heat of the ſeaſon only: ſo that there is no neceſſity for any Bees to have the care of this; nor are there any in the hive that have the office of ſitting to hatch the eggs. It is therefore an idle imagination, from which the male Bees are called brooders, or hatchers of the eggs, and has been received only, becauſe the nature of Bees has been hitherto unknown; nor has it been obſerved by thoſe who maintain this doctrine, that at every ſeaſon of the year the Bees breed, and young juſt hatched are therefore found in the hive before theſe pretended brooding Bees appear, which do not come forth but on the approach of a ſwarm. Thus that error, at this time ſo univerſal among us, aroſe merely from want of obſervation. The ancients have likewiſe erred who called theſe Bees drones; and moreover, if we attend to what Goedaert relates of Bees in the ſecond part of his Natural Met. Exper. 46, and which the learned Dr. de Mey alſo afterwards affirmed to be true in his annotations: we ſhall clearly ſee that the former, though he otherwiſe obſerves a tolerable method, is; however, ſo confuſed and void of all order on this occaſion, that his narrative cannot be really called a detail of things, but only a diſordered heap of words. He there confounds the humble Bees, Hornets and Bees one with another. For my own part, I eſteem nothing in the works of Goedaert but the figures; though even thoſe, notwithſtanding that they have been drawn according to living ſpecimens, have in many inſtances very conſiderable faults. But it is natural to men to commit errors, nor do I think myſelf free from them, and therefore we who follow the ſame ſtudies are obliged to aſſiſt and bring each other into the right way, but at the ſame time remembring our own weakneſs, we ſhould claim no ſuperiority over others. But when a perſon will not ſcruple to darken the truth on purpoſe, in order to depreciate another, or to favour his particular opinion, he is unpardonable. It were much to be wiſhed, that Goedaert had finiſhed his own obſervations.

Thoſe come nearer the truth, who, knowing more accurately the nature of the male Bees, called them the more noble kind, for they in reality live on the labours of the common Bees, and are at the ſame time of a more generous, mild, and tender diſpoſition; but that the males exclude the reſt of the Bees from the act of incubation is ridiculous. The eggs of Bees evidently ſtand erect, and they muſt not nor cannot be without hurting them: ſo far impoſſible it is to hatch them by ſiting on them. To which may be added, that when the egg is depoſited in an imperfect cell, as is often the caſe, there is no place for the male Bee that is ſuppoſed to ſit upon it, to reſt its body, unleſs it ſhould ſtop up the way, and be an inſurmountable obſtacle to the reſt of the Bees, when they attempt to perfect that cell. When the egg is at length grown mature by the natural heat of the hive, then there is excluded from it a very tender and ſmall Vermicle or Worm which did not want hatching, but needs now continual and perpetual nouriſhment: and not only the males, but even the females alſo are incapable of this buſineſs. To this may be added, that when theſe Worms have eaten ſufficiently, if they afterwards lie in a warm place, they are ſpontaneouſly and without the aſſiſtance of any particular heat communicated by the Bees, changed into Nymphs, and then again into Bees. This I myſelf have experienced in my own chamber, with reſpect to a great number of ſuch Worms, ſome few days after the beginning of September, before the nights began to grow cold. Nay, this experiment ſucceeded ſo far, that in ſome cells which I had opened, I already ſaw the eyes of the Nymph changing, and from a limpid or clear white, becoming of a beautiful but ſomewhat pale purple. This is indeed the firſt remarkable change the Nymph undergoes. I have likewiſe obſerved the ſame thing in the humble Bee deſcribed by Goedaert under the name of the Apis.

We ſhould particularly obſerve here, that there is ſuch a wonderful heat in the hives, even in the midſt of winter, that the honey does not concrete or loſe its original fluid conſiſtence, nor is gathered into grains or cryſtals, unleſs in hives in which the Bees happen to be fewer than uſual. The Bees, when they are fruitful, nouriſh, cheriſh, and warm their offſpring in the midſt of winter, and preſerve a mutual heat amongſt each other. But I do not know that this is the caſe in any other inſects, for even the Hornets themſelves, as well as Waſps, humble Bees and Flies, are all rigid and motionleſs in the winter; and in all that ſeaſon neither move nor change place, nor do they take any nouriſhment, nor diſcharge any fœces. Something ſimilar likewiſe holds in ſome ſpecies of the garden and other Snails, which, when they have been about that time cleared from all excrements, by continual abſtinence become a cleanly and agreeable food.

The Worm of the Bee, excluded out of its egg in this manner, and ſtript of its tender skin, muſt be afterwards, as I have obſerved, nouriſhed and fed. But as it never, like the Worms of other inſects which creep about, or are conveyed elſewhere, changes that place wherein it was firſt repoſited in its cell; hence this Worm wants a nurſe: of this laborious care and attendance the labouring or common Bees take the charge on themſelves, and nouriſh, cheriſh, and bring up this tender offspring, until, from a minute Worm, like a point, it is at length changed into a Nymph, and finally to a

Bee by accretion, and when arrived to this ſtate, it is no more increaſed in bulk. The Bees indeed daily procure and provide food for theſe Worms, with as much labour and ſolicitude as birds do for their young. And it is neceſſary that it ſhould be ſo, ſince the Worms of the Bees do not ſtir out of their cells till they are nouriſhed ſo far, that, acquiring the form of a Bee, they increaſe no more. This is common to all inſects, whether they are brought forth ſmall or larger, they never increaſe further when arrived at this ſtate. Nay, this law is ſo univerſally eſtabliſhed among inſects, that after they have acquired their laſt or moſt perfect form, which they retain for life afterwards, they always remain ſmaller or larger in their ſeveral kinds, in proportion as their Worms have by force of nutrition increaſed more or leſs while in that ſtate.

However, it is neceſſary to obſerve, that it is not honey with which the Worms of the Bees are fed; it is indeed another and peculiar ſubſtance; it is of a white colour reſembling the white of an egg when it begins to harden, or a white paſte made of flower and water; it is ſomewhat thicker than honey, and is of ſo mild a taſte that it ſcarce affects the tongue. From whence the Bees obtain or bring this food, or whether it be honey which is firſt changed in their own ſtomach or proboſcis into this form, and which they afterwards caſt out, as is uſual with Pidgeons and other birds, which give a half digeſted food to their young at firſt, I have not hitherto diſcovered. Be this as it may, the Bee-keepers who regard nothing but gain, and have no knowledge in any thing elſe, tell us ſome idle ſtories on this ſubject, though they ſcarce know any thing elſe of Bees, but how much a year is to be made by keeping them. The moſt ſenſible of theſe people call that ſubſtance ſalival honey. Nor is it to be doubted but the Bees can, when they pleaſe, throw up the honey again. Clutius indeed confirms this by a very remarkable example, whereof Voſſius makes mention in his treatiſe on idolatry. If the body of the Bees be gently ſqueezed on the under ſide, the honey will be preſſed out again and make its way up through the trunk. But notwithſtanding this, a doubt remains, whether the Bees diſcharge that honey out of their ſtomach, ſince they can hide a great quantity of it in the cavity of the proboſcis or trunk: probably the ſame thing is the caſe here as in Pidgeons who diſcharge a ſubſtance like chyle out of their craw. But though honey is collected, not made by the Bees, being firſt prepared by nature herſelf in the parts of flowers, and is only taken into their bodies by the proboſcis; yet I do not doubt but it is changed, digeſted, and converted into durable and good food for the young, not only in their body, but even in the proboſcis or trunk itſelf. This ſubject it would be worth while to examine more ſtrictly: nay, what is here advanced is the more probable, becauſe we obſerve, that the honey which the Bees gather from flowers is not always of one and the ſame conſiſtence, but is found ſometimes thicker, ſometimes thiner, ſometimes watry, ſometimes aromatic in the flower, and therefore it is neceſſary that it ſhould be afterwards prepared by the Bee to render it all alike *.

To return to the ſalival or diſcharged honey. I remember that I have often ſeen a peculiar ſubſtance diſtilling from willow trees, which I am inclined to think is very like this ſalival honey, and which Hornets, Waſps, the diurnal Butterflies and Flies all greedily ſeek after. It is particularly beloved by the Butterflies, which by ſhaking their broad wings often drive away the Flies that then ſit feeding thereon. It is ſingular that I never ſaw Bees buſy themſelves about this matter, which they might have eaſily carried into their hives to feed their young. When I further conſider that the Bees in the midſt of winter, and when they do not fly out, ſtill nouriſh their young, I have no further doubt of this matter, but am convinced that the ſtock of young Bees are nouriſhed with honey, thrown out or diſcharged in a very ſingular manner from the trunks of others, whatever the Bee-kepers ſay to the contrary.

How long the worm of the Bee feeds, before it is arrived at the perfect condition of a Bee, and has legs, I am not able to determine. But if what the Bee-keepers have aſſured me, as a certainty, be true, that is, that the young ſwarm may poſſibly ſwarm again in a month or ſix weeks, then it would be no difficult matter to compute that time, and I ſhould think that according to this calculation it may be completed in about twenty-four days in ſummer. Theſe Worms, however, do not increaſe in bigneſs ſo faſt as thoſe of Flies, for they are excluded out of a very ſmall and tender egg, and have at firſt very little motion. We muſt likewiſe conſider in this matter the hotter and more favourable conſtitution of the atmoſphere; for the temperature of the air only is ſufficient to detain a Worm or Caterpillar in the buſineſs of its change, ten days beyond the uſual time. This I have often experienced. This is ſo true that the change of a Worm into a winged inſect, which in the middle of ſummer is performed in the ſpace of a month: is ſometimes prolonged to eight or nine months; this happens principally when the preceding change happens in the laſt part of the autumn; for if in that caſe the winter cold comes on immediately after, the creature inſtantly becomes motionleſs, nor does it recover motion before the next year's hot weather comes, and

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* It is but of late that the ſubſtances of which wax and honey conſiſts, have been diſtinctly known; but it is now perfectly aſcertained. They are both collected from flowers. The antheræ or buttons placed on the filaments in flowers, contain a duſty ſubſtance, intended by nature for impregnating the ſeeds in the bottom of the flower, and of theſe the Bees make wax; they feed upon this ſubſtance firſt, and then diſcharge the remains, which have not been taken into the veſſels as nouriſhment at their mouths, and with a little moulding this becomes wax. The honey they find perfect in the flowers, either lodged looſe in the bottom, or in the glands called nectariæ.

nouriſhment is ready prepared for it, and for its future offspring. This is alſo the reaſon why ſeveral ſpecies of inſects do not die ſo ſoon toward the end of the year as in the heat of ſummer. Hence alſo, when the Butterflies of Silkworms are changed later in the year, they have ſometimes remained alive with me for ſix weeks after their laying their eggs, which is certainly a very ſingular incident. So great is the effect of heat and cold on theſe little creatures, that the one ſeems to give them life and the other immediate death, for death is nothing elſe but the ceſſation of natural motions. In the examples juſt now mentioned, the life of theſe creatures is prolonged by means of cold, ſince the ſtrength of life, and the fluids on which it depends, are ſlower diſſipated, by reaſon of the ſlower motion. This is a fact that indeed deſerves particular attention.

When the Worms of Bees are increaſed to ſome bigneſs, they begin to fill the whole cell in which they were placed, and turn themſelves as it were into a globe, as a Dog does when he lies down to ſleep; or, like that ſpecies of the Woodlouſe which turns itſelf round like the Hedg-hog. Now that I am upon this ſubject, I remember a very remarkable ſtory. One of our maid ſervants had at one time found a great number of Woodlice in the garden, contracted into round balls in the manner before mentioned, and thinking ſhe had found a kind of coral beads, ſhe began to put them one after another on a thread, but it ſoon happened that theſe little creatures, which roll themſelves up in ſuch a manner only for fear of harm, and appear as if they were dead, being obliged to throw of the mask reſumed their motions. On ſeeing which the maid ſervant was ſo greatly aſtoniſhed, that ſhe threw away the Woodlice and the thread, and cried out, and run away.

If the Worm of the Bee is taken out of its cell about this time, there is found under it, in the bottom of the cell, a kind of yellowiſh matter of a ſomewhat thick conſiſtence. This is the excrement of the Worm.

In the mean time, whilſt the Worm is thus increaſing in bulk, I do not doubt but it ſometimes, like other inſects, changes its skin, but how often it does this before it arrives at full bigneſs, I cannot determine. I have obſerved that when this Worm caſts its skin, and is changed into a Nymph, its pulmonary tubes alſo, ſituated in the body, change their skin and throw out through the orifices in the body a thin pellicle. Indeed, it ſeems to me very admirable, that this change of skin is ſo common to all inſects in general, that even Lice themſelves and the minuter Mites undergo it: nay, Spiders and Locuſts obey this law ſo perfectly that they caſt skins from their eyes, their teeth, and the very claws of their feet; even the horns are not excepted, which, though as they are ſmaller than a hair in the Locuſts, yet they likewiſe caſt a tender skin. The cruſtaceous and teſtaceous animals alſo, as the Crabs, Lobſters, and the like, change their skins. I have likewiſe obſerved, that when Serpents are caſting their ſlough, a skin is likewiſe thrown off from their eyes, and the inner ſurface of the skin is turned outwards.

At length my curioſity went ſo far, that I was not afraid to taſte and bite theſe Worms of Bees, in imitation of thoſe, who, from a beaſtly and depraved appetite, do not fear eating the Maggots that grow in cheeſe, that is, that ſpecies of Worms which skip or leap by bending their bodies, and again ſwiftly extending them. The Bee-Worms are of a very diſagreeable taſte, like that obſerved in the pancreatic juice of fiſh, and they leave a very offenſive or nauceous rancour like that of ruſty bacon in the mouth. Of the ſame opinion with me was the very experienced and induſtrious Peter Adrianus, who had then come to make me a preſent of ſome male Bees, and by his aſſiſtance has alſo greatly advanced this hiſtory. When theſe Worms are boiled, they have a ſomewhat more agreeable taſte; but if one continues chewing them, the former taſte prevails again.

Before I proceed further, I ſhall exhibit the Bee-Worms to the life, according to the various degrees of their bigneſs, as they continue growing: the thirteenth figure ſerves for this purpoſe. The letter *a*, Tab. XXIII. fig. XIII. repreſents a Worm juſt come out of its egg, *b c d e* are Worms nouriſhed longer and grown more mature; *f* and *g* exhibit others larger again and longer nouriſhed, which are here repreſented in the ſame manner as they lie in their cells: *i* expreſſes the Worm on its back, and beginning to draw the hinder part of its body inwards, and to move its head languidly.

In the ſame figure under the letter *h* I have delineated the Worm lying on its belly. In the back of this is ſeen a furrow of a blackiſh or pale blue colour: this line ſhews the ſtomach, which appears through the skin in that part, which I found to be all ſtuffed with a yellow matter. In the ſecond figure, under the letter *a*, Tab. XXV. fig. II. is exhibited a Worm, having attained its full increaſe, which ſtands up at that time in its cell, and ſhuts it up entirely: after this it remains very quiet and without any motion in the cell, and begins to ſwell at the 1ſt, 2d, and 3d annular diviſions of the body, becauſe its hidden limbs, and other parts, which had increaſed in bigneſs under the skin, are now inſenſibly ſwollen with humours, and therefore diſpoſe the Worm to change its skin. This will be very diſtinctly explained below.

If any one afterwards more accurately examines the Worm of the Bee, and views it with a microſcope, he will obſerve, as I have ſhewn in Tab. XXIII. fig. XIV. that it is compoſed of fourteen annular inciſions, *a a a*, including the head. In the head *b* are to be obſerved the eyes *c c*, the lip *d*, two little parts *e e*, which afterwards become the horns, and two other little parts *f f*, ſituated under the former, which ſeem as if they were articulated and afterwards grow into the teeth. Moreover, between theſe two little parts, and conſequently under the lip *d*, is preſented to view another ſmall and ſomewhat prominent or extuberant part *g*, which reſembles a tongue or trunk; and this increaſing by degrees, at length indeed conſtitutes the trunk of the Bee. Moreover, there is ſomething that hangs out of this little part above, like a ſmall nipple, by which the Worm diſcharges its thread to make the web, when it has eaten for a ſufficient time and is going to be transformed into a Nymph. In ſome other Worms I have ſeen beſides the tongue *g*, the reſemblance of a ſmall and tubular proboſcis, ſituate in the middle between the tongue and the lip *d*, by the help of which the Worm can probably take in its meat. But I ſaw this laſt mentioned tubular little part in the Worm, when I had firſt preſſed its body a little, and forced it forward, between my fingers, towards the head. Again, in other ſuch Worms, I have obſerved a horny or bony little part immediately under the lip. But thoſe other little parts behind this did not appear ſo diſtinctly to me. We muſt view theſe parts with a microſcope, and to that purpoſe firſt ſeparate and clear them one from another; for their colour, which is of a whitiſh yellow, prevents their being accurately viewed together, and in order to ſee them well one muſt uſe a very powerful microſcope.

The two eyes of the Worm *c c* are of a tranſparent white, and are limpid, ſo that they ſeem inflated as it were with a lymphatic fluid. In other inſects the eyes are uſually brown, blackiſh, green, red, blue, or yellowiſh; and in ſome few of a very full or faint purple, that is, according as the tunica uvea in the internal circuit of the eyes is coloured. It is evident from this example that the eyes are not alike in all inſects; nay, this diverſity with reſpect to the colour of the eye takes place equally in the larger and ſanguiferous animals: this I have particularly obſerved in Rabbits, in which the whole tunica uvea has been placed at the bottom of the eye, and then ſeemed to me, for want of blackneſs, unfit in a manner to detain and collect the rays of light for viſion; blackneſs, and even a deep brown, have this property, that they never reflect the rays of light that fall upon them, and for this reaſon alſo black paper takes fire much eaſier in the focus of a burning glaſs, than that of any other colour, which reflects the rays. But the ways or means of divine providence, which can bring all things to one and the ſame end, are innumerable. This I ſhall diſtinctly explain in the following pages with reſpect to the ſight of Bees; and at the ſame time demonſtrate therein the omnipotent wiſdom of God, from the eyes of theſe inſects.

Between the two eyes, and not far from the lip *d*, occurs a part of a yellow colour; nay, the lip itſelf and the tongue *g* are alſo yellowiſh. In the extremities of the ſucceeding horns *e e* there appears alſo a ſharp pointed yellow and browniſh little part. But as all theſe minute parts are of a faint colour and are pellucid, they cannot be diſtinguiſhed but with great difficulty.

In the other rings of the body, ten points of reſpiration are obſerved to be diſtributed on each ſide *h h h*, having no horny or bony parts of any other colour; as is the caſe in the Coſſus, in Silk-worms, and in moſt other inſects. It is therefore very difficult to diſcover theſe points, on account of the whiteneſs and general brightneſs of the Worm; indeed no perſon can accompliſh his deſign in this caſe, but by frequent and carefully turning of the microſcope to view the object in different lights. Theſe points appear placed in a kind of long fiſſure or ſlit, and are ſomewhat depreſſed. The pulmonary tubes or branches of the windpipe, which are internally joined to theſe points, are of a clear or limpid white colour, and glitter like mother of pearl; and in ſome worms which are not very fat, and have therefore a very pellucid body, they are ſeen alſo diſtinctly through it; as is alſo, through the tranſparent body of the Worm, the ſtomach, which in this Worm is uſually at that time filled with a yellow kind of matter like melted Bees-wax: the heart and ſpinal marrow are ſeen alſo diſtinctly through the body of the Worm, the former being placed in the back, the other in the belly.

This Worm has a very ſlow motion, and whenever it is diſturbed, it draws its head and tail, or the poſterior part of the body, a little inward. But if it be dragged out of its waxen cell, and any violence is by that means offered to it; then it will make other and more remarkable motions; for it ſometimes twiſts and bends itſelf forward, and ſometimes again backward. But if it be not moved or provoked, it lies without any viſible or conſpicuous motion; nor does it ever go out of its cell, until it hath grown into a perfect Bee.

I ſhall now proceed to the diſſection of theſe Worms. The Worms of Bees, as well as other inſects, may be diſſected by the help of various contrivances, which I myſelf have often uſed: firſt, then, I killed theſe Worms by different methods; I boiled ſome of them in ſpirit of wine; others I ſteeped in the alkaheſt liquor of Glauber, and in divers other coloured liquors: all which I have done, the better to diſtinguiſh their internal parts, which are all of the ſame colour. But theſe did not anſwer with the expected ſucceſs, becauſe the Worms abound with fat. If the Worm be caſt into ſpirit of wine, all its parts melt as it were and become watery. The parts are too much condenſed by boiling, and in the alkaheſt liquor likewiſe they are in the beginning too ſtrongly coagulated, but afterwards they change or turn into an aqueous fat or greaſe; therefore the beſt method that I know is, if one only ſuffocates theſe Worms in ſpirit of wine, and immediately afterwards prepare for the diſſection of them. It is of ſervice likewiſe to macerate them in coloured liquors, till they become, as far as they are capable of it, black, red, or yellow; or they may be even left to themſelves, that they may at length acquire a colour, by a ſpontaneous corruption: by this means, when the changes are properly watched, ſome of their parts ſhoot forth to view, which otherwiſe eſcape the ſight, or at leaſt cannot be viewed diſtinctly enough. It is indeed the nature of this Worm to have its body of a perfect white, and conſiſting of parts not very eaſily to be diſcerned; hence ariſes the vaſt difficulty of anatomizing it, unleſs we uſe the method mentioned above. All theſe things, however, need be of no conſequence, if one knew how to diſſect theſe Worms when alive, which yet is not eaſy to be done, ſince its parts contract themſelves at that time moſt ſtrongly, and alſo are in their own nature moſt extremely tender.

If the Worm be opened along the back, immediately there appears trickling out a ſort of ichor or watery humour, guſhing from the wounded veſſels, and from the heart. This is the real blood of the little Worm: after this are ſeen the muſcles ſituated under the ſkin, which move the annular diviſions of the body, and ſome of which go into the very heart itſelf. Next is ſeen the fat, and among this, in the middle of the back, the heart ſwelling out ſhews itſelf; this is indeed a long pipe, running through the whole back quite into the head, out of which the veſſels ſprout branching to all the parts. This, however, I never obſerved in the Worms I am treating of, but have frequently in Silk-worms. In the anatomy of the female, I ſhall mention ſome other circumſtances about the heart: if we purſue this diſſection further, preſently the ſtomach riſes to view, furniſhed with numberleſs pulmonary tubes, which, being made up of fibres eaſy enough to be diſcerned, if it is cut, recedes very eaſily from its internal coat. This to appearance is membranaceous, and is three times thinner than the ſtomach itſelf; this ſame tunica, moreover, like the moſt tranſparent kind of glaſs, is perfectly clear, as well as moſt equally ſmooth, which indeed is found in other inſects likewiſe, and more than all the reſt in Silk-worms. In the laſt Worms I diſſected, this coat, or internal part of the ſtomach, was always ſwollen with a ſort of matter of a deep yellow colour, a little clammy, which not only filled the whole cavity of the ſtomach, but in the back, where the heart is placed, was diſtinctly ſeen through the heart and the body. In the Worms of Hornets, that inner coat of the ſtomach ſhews to appearance like a piece of net-work, the moſt curious that can be ſeen, and is of a purple colour. In the lower part of the ſtomach, where the pylorus lies, are four little veſſels, through which there runs a matter of a yellow colour, a little inclined to whiteneſs: theſe are firmly knit to the fat and air-pipes, and appear here and there through the fat, and winding about are carried over the body in wreaths; to me, indeed, it ſeems difficult to find out what kind of particles theſe are, for they do not appear to be like the ſaffron-coloured veſſels, which the illuſtrious Mapighius has deſcribed in Silk-worms, being what I have found hitherto in all inſects, though not always tinged with this yellow colour. Whatever be the caſe, after long and unwearied ſearch I at laſt perceive, that in their extremities, they, as the cloſe guts or cæca of hens, are cloſed up: to diſcover this I uſe the following method, viz. with a fine forceps I take hold of the gut, or of the end of the ſtomach into which the veſſels run, and then ſlowly and carefully draw them out from the fat and intwined membranes, and pulmonary tubes; ſince they could not otherwiſe be diſentangled without the utmoſt difficulty. If theſe cloſed veſſels are macerated for a little time in ſpirit of wine, then they appear as if they were covered over with glandules, which kind of glandules may likewiſe be obſerved in other inſects. I have called theſe in the Coſſus ſaffron-coloured veſſels. In Bees it is extremely hard to bring them into ſight.

The fat alſo of this Worm, as in the Coſſus, conſiſts of globules, and theſe very globules in ſome meaſure reſemble the globules of fat in the Coſſus; but the fat in this Worm I am treating of is not loſt during its growing ſtate. Wherefore it may ſtill be ſeen, after the creature is changed into a perfect Bee; if this fat be examined more accurately, beſides numberleſs more minute particles, there are likewiſe to be obſerved in it ſome little oily lumps, ſuch as I have before repreſented in the fat of the Coſſus; but the ſtructure of the fat cannot be more exactly examined, unleſs we view it laid on a very thin plate of fine glaſs, a ſingle microſcope being paſſed between, right againſt the ſight. In the fat, which is mixed with extremely thin membranes, and with the pulmonary tubes, ſome ſmall particles are here and there ſeen, wrinkled and contracted, and ſomewhat inclining to a pale purple, and in other parts nearly whitiſh. Theſe are the beginnings of the air bladders, which afterwards in Bees are filled with air, and mix themſelves with the pulmonary tubes, to which they have hitherto but a ſlight coheſion; juſt as the lungs in animals, that have not yet uſed reſpiration, ſo theſe air bladders are contracted in theſe ſubjects.

On the oppoſite ſide, near the head of the Worm, there appear ſome other veſſels, which curl like the tendrils of a vine, in the ſame manner as the cloſed veſſels juſt deſcribed; nay, and they are ſo fimly braced with membranes, fat, and pulmonary tubes, that I have found it impoſſible as yet to ſeparate them; whence I have alſo been unable ſo accurately to diſcover their ſtructure. Theſe veſſels are double, and at laſt meet in one little tube, which, after that, ſhoot on the outſide under the tongue of the Worm, and there become ſtronger and tougher, and then ſwell outwards in a kind of ſoft pimple, pervious by an opening: from this prominence a glutinous humour, the matter of the filaments, is ſent out; ſo that theſe veſſels may be conſidered as the parts out of which the Worm draws its threads. When the Worm, having taken ſufficient nouriſhment is ſoon afterwards to be changed into a Nymph, then by the help of theſe little threads it covers in its little cell, and at the bottom, and on the ſides within, covers it over as it were with glue. I have ſeen in ſome Worms likewiſe, that theſe tubes, not far from the part where they iſſue forth under the mouth, have divided themſelves into two branches, which, however, as I have already mentioned, I have not as yet been able to trace further. In the mean time I believe, that they end in the cloſed appendages, as is the caſe in ſilkworms. Whenever theſe tubes are pierced through tne middle, in that part where they meet in one little body, there iſſues thence a glutinous matter extremely tough, and capable of being drawn out into long threads. The ſame thing is alſo obſerved in the glue of Silk-worms, not yet drawn out into threads, and in other inſects, and even in ſpiders themſelves. This, however, is to be obſerved only in thoſe Worms that are near the time of their tranſmutation into Nymphs.

I have not perceived any other parts in the Worm, beſides thoſe I have already explained, ſince the veſſels in it, which carry and return the blood, are ſo very delicate and tranſparent, that I was not able to diſcern them. For the ſame reaſon I could not deſcry theſe very parts even in the Coſſus, though there are inventions of art, by the aſſiſtance of which we may come to the knowledge of them. In Silk-worms I ſucceeded by the following method, which I have repreſented in the fourth figure, viz. I provide myſelf with a little glaſs tube, ſuch as is here delineated, which I take care to have made like a vial in the middle, Tab. XXIV. fig. IV. *a*, at one end *b* to be drawn out to the utmoſt ſmallneſs, and at the other end *c* made thicker and broader, in order that the air blowing into it, may be conveniently forced in at this end: this done, I fill the little pipe with ſome thin liquor coloured, not however of a very penetrating kind, let in through the thicker end *c*, and then with the greateſt caution perforating the ſkin *b*, I thruſt the thinner end into the heart. This may be done eaſily enough. By theſe means, and then gently blowing into it, the heart, and many of the veſſels ſhooting out from it, may be filled; and further, though no other parts are diſcovered in theſe Worms, ſtill it is of uſe to take notice in them, both of the pulmonary tubes, and the ſpinal marrow. As for the marrow, indeed, though by reaſon of its exceſſive yielding and ſoftneſs, I could not examine it with any exactneſs in the Worm, yet I had no difficult taſk to diſcover it in the male Bee, of which when I come to treat, I ſhall deſcribe it as there delineated.

There are, as I ſaid, ten points of reſpiration on each ſide of the body, in all twenty; and there is the ſame number in Silk-worms, and in the Coſſus; but there is this remarkable difference, that both in the Coſſus, and in Silk-worms, only eighteen of theſe points with reddiſh tufts, of a ſubſtance between horn and bone, ſuffer themſelves to be diſcerned; but the tenth pair of them is not ſeparated ſo plainly, which perhaps is the reaſon that the incomparable Malpighius does not deſcribe twenty, but only eighteen of theſe points in Silk-worms. The twenty pulmonary tubes, which in the Worm of the Bee ariſe as it were from theſe points, are carried inwardly into the body, and have all a mutual communication with one another: a kind of little tube runs all along from one point to another, ſo that in this manner the anaſtomoſis or inoſculation of theſe veſſels is propagated through the whole body. The ſtructure of theſe pulmonary tubes is in truth exceeding wonderful, for all of them conſiſt as it were of curled rings, which being twiſted together in the cloſeſt manner imaginable, and intwined with one another by the fineſt filaments and moſt delicate membranes, make the union ſo completely ſolid, that the air can no where pervade, except through the middle cavity, which is always open. Theſe rings are alſo twiſted cloſer in ſome of the tubes than in others, but indeed the fabric diſplays the greateſt artifice in thoſe places, where theſe pipes divide into branches and ſhoots, for there the rings are ranged with ſurpriſing ſkill one cloſe to another, and are joined together by the intervention of the lengthening, abbreviating, and crooked rings. All theſe things may be ſeen very beautifully, if one puts theſe pipes on a very thin piece of glaſs, and afterwards views them againſt the light: this is indeed a very uſeful contrivance. They may alſo, in order to diſtinguiſh them the better, be placed on thin, coloured, black, or green glaſs. Theſe pulmonary pipes or tubes are always open, as I have before mentioned, which is likewiſe the caſe in the human ſpecies, and in other animals, but principally in regard to or about the cartilaginous rings placed in the neck, ſo that therefore the air in the human body, or any other animal, which hath once breathed or reſpired, can never be entirely driven out of the ſubſtance of the lungs. We muſt further obſerve, that theſe pulmonary tubes are in this Worm diſtributed in ſuch a manner, that the brain, the nerves, and even the eyes are furniſhed with branches of them; this I ſhall afterwards ſhew in the anatomy of the eye, the ſtructure of which, too delicate for all deſcription, proclaims the infinite wiſdom of the ſupreme Architect. Next we are to explain the ſixth figure in this plate, which exhibits ſome of the viſcera of this Worm.

The letters *a a*, Tab. XXIV. fig. VI. denote the ſtomach, furniſhed with infinite air-pipes *d d*, which are affixed to it: *b* is the gullet. *c* Exhibits ſome glandulous little parts, which are ſeen diſtinctly through the tranſparent ſtomach. The ſtomach alſo has towards its hinder parts ſome muſcular circular fibres *e*, which ſerve to move its contents. *g g g g* Are four veſſels, inteſtina cæca, or cloſed guts. *h h* Shew the inſertion of the cloſed guts or cæca below the pylorus *f*. *i* Exhibits the reſt of the inteſtines of the Worm, the craſſum and rectum, or the thick and ſtraight gut, to the extreme end of which a ſmall part of the ſkin is likewiſe obſerved to adhere. *l* Repreſents the delicate coat of the ſtomach, replete with coagulated contents of various kinds, which are deſigned by the darker parts in the figure. Fig. V. *a*, are the pipes appointed for the matter of the web, or the bags wherein the ſubſtance of the future threads is prepared. *b* Shews the place where theſe points are joined one to another. *c c* Exhibit the diviſions of theſe pipes. *d d d d* Is the place where thoſe pipes that contain the matter of the web are broken off, and beyond which I could not at this time proſecute their courſe: what increaſed the difficulty was, that other matters, which were likewiſe to be inveſtigated, took up all the time I then had. I likewiſe find the ſame difficulty of tracing theſe veſſels in the Worms of the Hornets; which however might have been conquered much eaſier in the latter; but it is as rare to get ſo great a number of Hornets, as a ſufficient number of their Worms.

The firſt figure repreſents the pulmonary tubes of the Worm, as may be ſeen on each ſide, under Tab. XXIV. fig. I. No. 1, 2, 3, &c. and the letters *a a a*; for twenty ſuch tubes are ſeen in this creature. It likewiſe appears in this figure, in what manner the pulmonary tubes of the ſame ſide have a communication with each other *b b*, by means of tubules carried from one orifice to the other; and have the tubes of each ſide meeting each other from the oppoſite ſides of the body, and are alſo united together *c c*. Finally, the branches are ſeen there, which ſpring from the middle trunks of theſe ſeveral tubes. The Worm is here exhibited and laid entirely open, and without its viſcera, fat, and membranes, all which I carefully waſhed off with a little water, by the help of a fine pencil. Though the orifices *d d* of the pipes are ſituated under the skin, yet I have delineated them, as if they appeared or were prominent out of it; which particular, though it be contrary to nature, yet I have obſerved in this place, that my deſcription may be the more eaſily underſtood. The other two ſpiral little parts, fig. II. and III. *e*, *f*, expreſs the rings of the pulmonary tubes. One may very diſtinctly and beautifully ſee theſe, if a hair of a man's head be paſſed through a ſmall part of a pulmonary tube, and both extremities of the hair be afterwards glued or affixed with wax; if that part of the tube be then ſeparated or taken away, with ſmall tweezers, or ſtretched out by needles, it will be ſeen diſtinctly how theſe contorted or twiſted rings are longer in one part *e* of the tube than in the other *f*. Without this contrivance, theſe rings may be eaſily diſcovered, by the help of a microſcope.

But I ſhall proceed further. I muſt obſerve, that when the working Bees have maintained the Worms here deſcribed, until they are arrived to their full bigneſs, theſe Worms afterwards abſtain from all food; and as they lay before in their little cells, contracted as it were into a globe or ball, ſo, on the contrary, they now ſtand erect, and thus fill the whole cell from top to bottom. Theſe Worms about this time, cover the inſide of the cell, from the lower to the upper part, with threads; in which work, however, this difference deſerves particular notice, that is, that the web, which lines or ſurrounds the foundation and ſides of the cell, is more membranaceous, but that which is on the extremity more thready. This difference ariſes becauſe the Worms do not always ſpin complete webs, but ſometimes diſcharge on the filaments, or thread already ſpun, a great quantity of the gluey matter, which ſhould have made the threads, and by this means daub or waſh it as with glue. This I have likewiſe often ſeen in other inſects; nay, I have had the good fortune to obſerve it even in the Silk-worms, however rare or uncommon it may ſeem; for whenever any little knots occur in ſilk thread, theſe are owing to the diſcharged matter which has flowed out too plentifully together. Nay, if the imperfect Silk-worm when expanded, be glued to paper, it does not appear thready, but alſo membranaceous; this thread is nothing elſe but a ſoft extended ſilk, afterwards hardened by force of the air. It is remarkable in the Silk-worms, that water alone has the power to diſſolve their unſpun ſilky matter; whereas, on the contrary, ſpirit of wine, vinegar, and other ſuch liquors will coagulate it immediately. In like manner as the Worms of Bees, and thoſe of Hornets perfect their web from ſpun threads, it is indeed very beautifully and wonderfully finiſhed in the end. It is perfectly white and fine above, but it is all membranous and yellowiſh below. In regard to their work, I obſerve this further difference, that the Worms of the Hornets do not draw all their webs to the ſame height, as the Worms of the Bees do; and hence it happens that their cells differ very much among themſelves in reſpect to height. Their webs alſo conſiſt of ſtronger threads, and are of a rounder figure, and uſually drawn higher than the Bee-webs, nor are they ſealed up with wax, as is common in Bees. The ſeventh figure ſhews the web, prepared by the Bee-worms; it is formed above into a ſpherical figure, and has very conſpicuous filaments, Tab. XXIV. fig. VII. *c*; but on the lower part *a* it is membranaceous and much thicker; and at length it becomes triangular, towards the baſis of the cell, and exhibits a tranſparent Nymph *b* on the inſide.

After the Worms of Bees have brought their webs to this degree of perfection, the working Bees have new buſineſs, for it is then incumbent on them to cover with wax all theſe caſes which are arched as it were over the head of the Worm, and conſequently to ſeal up the Worm itſelf with the greateſt circumſpection and exactneſs in its cell. This caſe ſeems to me to be altogether neceſſary, for if the web was not covered and ſealed up above with wax, it might poſſibly be preſſed in by the Bees running up and down thereon, and conſequently the ſubjacent young and tender members of the Worms which caſt their ſkin a little before might be injured: beſides that, the operculum or cover of wax contributes much to preſerve the heat, by the aſſiſtance of which, both the evaporation of the ſuperfluous moiſture, and the ſubſequent change of the Nymph into a Bee are promoted. The web we have hitherto been deſcribing has alſo this further uſe, that at the time the Bee-Worm changes its ſkin, and diſengaging itſelf from the latter, is tranſformed into a Nymph, it is then prevented from ſlipping out of its cell, which might very eaſily happen if the cells were not covered or thus ſhut up, as I myſelf have learned from experiments. I at one time carried ſome of theſe Worms about me, which being as it were hatched by this heat alone, came to that perfection, that the Nymphs aſſumed the form of Bees: I then ſaw theſe Bees running quickly up and down in my box, ſo that I could not really help admiring what had happened: and from this experiment I learned one thing, and that is, that I might thus know for certain how much time was neceſſary for the Nymph to grow into a Bee; but I have not as yet been able to inveſtigate this matter fully, being then engaged in other neceſſary buſineſs. I have hitherto only obſerved the changes which happen under the time of growth, and at the ſame time I have thus experienced, that heat alone will hatch Bees, and the incubation or ſitting of other Bees is not neceſſary, as ſome authors have feigned. I began the experiments juſt now mentioned about the end of September. If the web I have deſcribed be cut open in that part where the head of the encloſed Worm is placed, the Worm afterwards will come out of it there, when upon changing its ſkin it is transformed into a Nymph.

The Worm after it hath covered itſelf with this web remains entirely at reſt, and does not move in the leaſt; it keeps the place which it at that time filled, and remains quiet to the end of its tranſformation. But if the diſſection of the Worm be undertaken at that time, beſides the cæca or cloſed veſſels before deſcribed, there alſo appear a great number of very ſlender veſſels, which are ſituated on the inteſtines near the pylorus, where the cloſed veſſels are inſerted, and ſeem to me to be of the ſame nature with thoſe veſſels which Malpighius calls vaſa crocea, the ſaffron coloured veſſels in the Silk-Worms. At the ſame time the cæca or cloſed veſſels themſelves are ſeen. Whether theſe very delicate veſſels are in the Worm from the beginning, and afterwards only increaſe with its growth, does not yet appear. But if they be, they are much larger in the Bee than they were in the Worm: I have never found them of a yellow colour in Bees, as I have done in the humble Bees. I have ſometimes ſeen the excrements lie coagulated in theſe veſſels in the females, and indeed occaſionally in the common Bees. I find great difficulty to diſcover the real uſe of theſe cloſed veſſels, whether they ſecrete a particular humour in their cavities, which muſt be diſcharged out of the body, or ſuch a liquid as changes the contents of the other inteſtines; or are they analogous to the cæca which are found in other animals, but particularly in Birds and in Rabbits? The uſe of the cæca in other animals is not yet ſufficiently known, yet it is certain that excrements of the ſame with thoſe of the great guts are found in plenty in them. Had not theſe veſſels been ſo regularly divided into four, and had they been of ſuch a length, and inſerted even into the inteſtine under the ſtomach, one would incline to conſider whether they did not belong to the bladder of poiſon of the ſting, which I ſhall afterwards deſcribe in the common Bee; but this doubt may be eaſily ſolved, if one ſhould diſſect the Worm of a male Bee. The time for getting theſe Worms is now paſt, ſince I am now writing this on the firſt day of September.

Further, in this ſtate of the Worm the ſtomach is much more contracted than it was before, and appears like a ſmall gut: it is of a whitiſh colour, and its yellow contents now diſappear, being totally waſted. We likewiſe obſerve, that when that Worm is but a day, or half a day older, its ſtomach becomes ſhorter; but the vaſa crocea, or yellow veſſels, are much ſtronger and more viſible. A little below the place where the vaſa crocea are inſerted, the great guts may be ſeen more beautifully than in the Worm that is not yet covered in its cell. Theſe are joined to the ſtomach, and now become ſomewhat longer, and begin to bend or turn themſelves. Behind theſe are ſeen one or two parts ſo tender that they cannot be accurately examined.

The fat that is found in the Worm when in its web, very eaſily ſeparates from its membranes: hence it happens that the contracted pneumatic veſſels become at this time more conſpicuous.

The Worm whilſt at reſt in the manner juſt mentioned, ſwells conſiderably about the breaſt, but not ſo much about the head; and after this it begins likewiſe by degrees to grow thicker, and to ſwell out about the ſecond and third annular inciſion: the reaſon of this is, becauſe the limbs of it which have increaſed inwardly, are inſenſibly diſtended with fluids. We likewiſe here ſee the legs and wings, afterwards the head, breaſt, belly and trunk, and finally, the whole form and ſtructure of the

Bee that is to be produced from thence, all ſhewing itſelf under the skin. But the legs are bent together as if they were folded up, and are weak and very tender: the muſcular fibres likewiſe are like glue, and they appear fluid like water, on account of their abundant moiſture, ſo that they can by no means move themſelves: ſo great is the extenſion and inflation which they undergo, ſo that for this reaſon, incomprehenſible changes muſt afterwards happen in them. Nor are theſe following changes peculiar to the muſcular parts alone; they are obſerved alſo in the nerves and in the ſpinal marrow, for they are likewiſe ſubject to very viſible extenſions, tranſmutations, contractions, and even tranſlocations. This is no where more manifeſt than in the Perla, or Dragon-Fly, of Mouffet, and in the Ephemerus, when theſe little inſects change their forms; for in the Perla the ſpinal marrow is extended ſo much that it becomes twice as long as it was in the Worm; and ſomething ſimilar is likewiſe obſerved in the optic nerves of the Snail.

The legs in particular, and alſo the horns and trunk *, are then very conſpicuous when the Worm of the Bee is diſtended ſo much; and by the ſame means the whole figure of the included Bee becomes, by degrees, viſible through the skin, and all the diviſions of the head, breaſt, and belly come in ſight. But at length, when the skin opens along the back, and the skull of the Worm ſeparates in three places, there the Worm aſſumes the form of a Nymph, that is, it after this change ſhews out beautifully, and more perfectly formed, the limbs and parts that were before hidden: hence all the parts may be ſeen there more clearly and diſtinctly than in the Bee itſelf; ſince that feather-like down which is ſeen on Bees, is at this time in the Nymph. The ſtructure of the trunk is likewiſe remarkable, and is moſt manifeſt here in all its parts; and therefore it can, on account of its ſituation and immobility, be much more elegantly and clearly diſtinguiſhed, than when this little inſect is become a perfect Bee, or hath been transformed into the flying ſtate, by a real growth of the parts, not a fictitious metamorphoſis, according to the fanciful and viſionary opinions of authors who have written to this time. All the changes of inſects are no more than a ſlow accretion of the limbs and parts, and therefore are analogous not only to thoſe of other animals, but alſo to thoſe which we obſerve in vegetables, as has been before ſufficiently explained and demonſtrated at large.

The creature is in this ſtate of the Nymph exceſſively, nay, amazingly tender; for almoſt all its limbs are extended and inflated with abundant humidity; the former skin is thrown off, the pulmonary tubes in the body have changed their integuments, and are again ſwollen with new air; nay, it is wonderful and utterly incomprehenſible, that the pulmonary tubes, whilſt they are caſting their integuments, do not put off ſimple membranes, but as it were entire veſſels compoſed of annuli or rings; ſo that by this means the internal pulmonary tubes which have ſeparated from the other, are thrown out of the body at the external orifices or points of reſpiration, having the ſame form with thoſe which remain in the body. In the ſame manner likewiſe the ſtomach and gullet, and the inteſtines through the whole body change their skin; which, however, is very difficult to obſerve, unleſs one ſhall immediately examine the exuvia or skin when it is juſt caſt off; or better, if we know how to take off the skin from ſuch a Worm, at a fit time, by art. The ſtomach wonderfully ſhews this in the Worms of Hornets, for theſe in like manner diſcharge their contents or excrements, and together with them the whole inward coat of their ſtomach, which is of a purple colour, ſo that the little maſs ejected weighs ſometimes more than three grains. From the number of ſuch coats as are found compacted in the cells of the Hornets, and laid on one another at the bottom of the cell, it may be very certainly computed, how many times the Hornets have brought up their offſpring from the Worm ſtate in the ſame cell.

In the Worms of the Bee it is particularly remarkable, that when they are changed into Nymphs, all their limbs and other parts, their legs, wings, horns, and proboſcis or trunk, and all the reſt of the body have pulmonary tubes: theſe tubes are likewiſe filled with air at the time their limbs and other parts are ſwelling, and by force of this air they likewiſe promote the due expanſion of the ſeveral parts: this is ſeen moſt eminently, when the Nymph, by changing its laſt skin, becomes a perfect Bee.

In the Cameleon, which is the only ſanguiferous animal that has lungs, which agree in ſome reſpect with the lungs of inſects, by reaſon of their branching pipes, the propelled air is likewiſe of the ſame uſe in expanding or diſtending the parts. But it is only for the purpoſe of extending the creature's tongue that this happens in that creature, though there are, beſide this mechaniſm, ſome muſcles that likewiſe contribute to the thruſting out this tongue: it chiefly, however, depends on the air which is forced out of the lungs for that purpoſe, into the double cavity of the tongue. I have likewiſe obſerved the organs of hearing, and the ſpleen in the Cameleon, however boldly ſome very induſtrious gentlemen in France, who have publiſhed the anatomy of the Cameleon, may aſſert that it wants theſe parts. Theſe authors have likewiſe committed great errors in regard

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* Since this author wrote, the French naturaliſts have made many nice inquiries into the ſtructure of this inſect. They in general confirm the doctrines he has eſtabliſhed, but in ſome points they have improved on them. They have diſcovered that beſides the trunk, the Bee has a real mouth. This is ſituated in the fore part of the head, and may indeed be ſeen without great difficulty. By means of this the Bees are able to feed upon the farina of flowers, from which afterwards is made wax. This author thought they could not feed on it, becauſe it could not paſs their trunk; but I have taken out of the ſtomach of a Bee the farina of a bean flower in its proper form.

to the cornua or horns of the uterus, ſince they have neither accurately delineated nor exactly deſcribed them. The pulmonary tubes alſo are not repreſented acute enough by them. I would not however have any perſon think I ſay this from a love of cenſure, ſo far from it that my ſole view is that the true face and diſpoſition of nature may be expoſed to the eye. I wiſh others may paſs the like cenſure where due on my works; nor do I pretend to doubt but I have committed many errors; it is ſufficient for me that I can moſt freely aſſert, that I have not wilfully deſigned to miſlead the reader in this treatiſe, I likewiſe think the ſame of ſome other, but very few authors; for the deſire of writing is ſo prevalent now-a-days, that men publiſh books filled only with the fancies of their brain, and thus miſrepreſent God and his works; heaven forbid that I ſhould ever do this, truth and a religious ſcrupulouſneſs of mind ought every where to prevail in deſcribing natural things, becauſe they are the books of the divine miracles, unleſs he who writes aims to deceive himſelf and others, and ſuch a one ſhould know that all things are revealed in time.

Let us now return to our ſubject. Theſe Worms then weave over or cover the inſide of their cells with threads, they alſo diſcharge their excrements into theſe cells, and there at the ſame time, caſt a thin ſkin and their old pulmonary tubes: hence if all theſe things be done ſeveral times over, that is, if in the cells of the ſame hive, freſh eggs be laid and young Worms be continually hatched in a ſucceſſion for ſeveral years; the cells muſt neceſſarily become from time to time leſs and narrower, and the Bees muſt be obliged to leave the old combs, and to build themſelves a more convenient edifice: the honey alſo that is lodged in ſuch foul and dirty cells, is not to be called virgin honey, nor the wax of the combs virgin wax. Since both of them abound with a great deal of filth, which ought to be ſeparated before they are fit for uſe. The honey which the common people uſe is very impure, for it is preſſed out of wax, after the purer part of the honey has run out, and it is accordingly ſold at a low price *.

If any perſon is deſirous to examine the web before mentioned, let him ſteep only part of it, together with the wax adhering to it, for ſome days in rectified ſpirit of wine; thus the wax will fall into little lumps, and the web will be manifeſt alone: if an entire waxen cell, while it is yet ſealed up with its Worm or Nymph in it, be put into rectified ſpirit of wine, then all the Nymph's little body, which is encloſed in the web, and cannot be taken out of it, but by cutting the web, preſents itſelf to view. This contrivance whereby we ſteep and diſſolve the wax by ſteeping or ſoaking it in a proper fluid, in order to ſee the web, has this further advantage, that one may by this means know very exactly how many times the Bees have brought up their progeny in the ſame cell, for it is certain that as many webs as are found in one cell, ſo many eggs have been hatched there. When the wax is thus carefully ſeparated from the web by ſteeping it ſo that the delicate texture of it is not injured, the web will then be found to repreſent or expreſs very beautifully the hexagonal figures of the cell, particularly in the lower part, as may be ſeen in Tab. XXV. fig. III. under the letter *g*. This web is likewiſe about the baſis and angles of the little cell, always ſomewhat thicker and blacker than at the upper part, being there more membranaceous and of a yellower colour: from what cauſe this difference proceeds is ſtill a ſecret to me. If any one deſires to diſcover very ſuddenly the web ſo often mentioned, let him make the waxen cell boil for a moment over the fire in ſpirit of wine, or in oil of turpentine. If an old cell be cut open with a diſſecting knife, we ſometimes obſerve the foundation of the cell, which is otherwiſe wonderfully thin and delicate, half as thick as the ſilver coin called an imperial, on account of the ſeveral webs, that have from time to time been laid on it. This condition of the web has impoſed on ſome ſo far as to make them believe, that every Bee builds its own reſpective cell, for they ſaw that all of theſe webs were ſevered from each other, when the broken wax was ſeparated from them, as one may eaſily try if he ſteeps or ſoaks the little cells for ſome days in brandy.

The webs are alſo of this further advantage to the combs, that they make them much firmer and ſtronger, and hence one may with leſs danger remove and carry elſewhere the hives in which the Bees have engendered for ſome time, than thoſe in which the wax is new. Beſides that the combs, ſtrengthened with theſe webs, do not ſo eaſily melt in very hot weather, or blend together, when they are turned upſide down. That the filaments or threads of the web may come in ſight more diſtinctly, there does not require much labour in preparing it, for if one only cuts off the upper part of one of the cells, which is covered with wax, with ſmall ſciſſors or a fine knife, ſtrips it of the waxen cover, and then places it under the microſcope, it will appear moſt evident, from the diſpoſition and manner wherein the threads are placed over one another, that the Worm of the Bee does in reality ſpin. If an entire cell, ſteeped or ſoaked in ſpirit of wine, throws off the wax, then both parts of the web, as well that which is diſcharged in the form of threads, as that which is like a membrane, being now joined together, nay, the whole figure of the web, which is hexagonal below, and ſpherical above, may be ſeen.

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* What is called rock honey in ſome parts of America, is the produce of a peculiar kind of Bee, lodged in a very ſingular manner. This Bee makes no regular comb, but notwithſtanding that, it preſerves its honey in waxen veſſels: the honey is clear as water, and very thin. The Bees hang their cluſters of caſes to a rock; one is firſt made, and is very ſecurely faſtened; then others are hung to that, in the manner of grapes in a bunch. Theſe cells or caſes are larger than the biggeſt grapes, and of an oval ſhape; each has at firſt an aperture at the upper part, in which the Bee puts the honey; when it is full they cloſe this aperture: forty of theſe caſes will ſometimes hang together, and the honey is excellent, and in large quantity.

Before I enter upon the deſcription of the Nymph more accurately, I ſhall beg leave to obſerve, that the Cochineal inſect if ſteeped or ſoaked for ſome time in ſpirit of wine, appears almoſt like our Bee-Worm; its body being divided by many annular inciſions: but there is this difference, that it is ſhorter and thicker than the Bee-Worm, and it alſo exhibits ſome veſtiges of legs. The Cochineal Worm, as I have heard and been aſſured by ſome who ſpoke poſitively, is produced out of an egg, which the parent inſect lays on the leaves of that very well known American plant called Tuna. When theſe Worms are firſt come out of their eggs, they are as ſmall as thoſe minute Worms which are newly produced in cheeſe: they are increaſed afterwards ſo much by means of the food, which they get from the leaves of this plant, that in a ſhort time they cover the whole ſurface: nay, they multiply to ſuch a degree that in the ſpace of one year, they will occupy or poſſeſs a field that has an hundred ſuch plants, and may be collected from thence for exportation four or five times yearly. There muſt only be care taken that the plants be clear of all other inſects whatſoever, and that no fowls be admitted into the place; for both will greedily hunt after and feed upon theſe Worms. When the owner is inclined to gather theſe Worms, he firſt conſiders whether they are arrived at their full ſize, and then ſome throw aſhes on them, and bruſh or gather them off the plant, and then dry them in the ſhade: if theſe Worms are left longer to themſelves, they then fix themſelves to the leaves when they are about to change into Nymphs by accretion: and the Nymphs, caſting off ſome time after a thin skin, are changed into very ſmall and almoſt orbicular winged Beetles, of a brown black colour, adorned with bright purple ſpots, and diſtinguiſhed into males and females, who ſoon after coition lay eggs again. Theſe Beetles are not, like the Worms, uſed in dying, though they are ſometimes brought to us mixed with Cochineal, as I myſelf have ſeen, and now have ſome that I picked out of that drug in my cuſtody.

In our country alſo on the leaves of the lillies, Worms are often found which are ſomewhat thick and of a pale red colour, like Cochineal, but they differ from it in that they are furniſhed with ſix remarkable black legs, and have a very conſpicuous head. Theſe Worms are transformed in a very ſhort time into an oblong bright red Beetle with black legs and horns. This Worm has one thing peculiar to it, which is that it covers itſelf with its own excrements againſt the ſun's heat, and by that means renders itſelf in a manner inviſible; ſince it walks over the leaves of lillies covered with its excrements. I have likewiſe in my collection of inſects ſome little creatures not unlike the Cochineal Beetle, only that they are ſomewhat leſs and in ſome meaſure different in regard to their colouring. Hence I am inclined to think that the Cochineal may probably be diſcovered and fed in our country, though I have never yet found it. This ſpecies of Beetles, which have all knobbed horns, are by our country people called Lieven Heers Haantjes, or Onze Vrouwen Haantkens: but I ſhall now return to the Bees.

The Nymph of the Bee-Worm contains nothing elſe but an elegant diſpoſition and well-ordered repreſentation of all the limbs and parts of the future Bee; which, as they have been to this time increaſing, at length become externally conſpicuous; but they are immoveable until the humours with which they are filled and diſtended are exhaled and diſſipated: after that the creature can move them. Hence it is that the Bee while in the Nymph weighs conſiderably more, than when it is changed into a perfect Bee. Before I exhibit the parts and limbs of this Nymph, I ſhall deſcribe its parts while yet in the Worm, with more accuracy and method than has been hitherto done by others. In doing this I ſhall follow the order according to which the Worm inſenſibly and naturally approaches to the change of its skin, or to the diſcloſure of theſe hidden members: it is as follows. The old skull, which is to be immediately caſt off, becomes inſenſibly filled with a limpid humour, by force of which it is ſeparated by degrees towards the foremoſt parts from the head; hence the horns, teeth and trunk, which lie folded and complicated together under the skin, are diſpoſed in ſuch a manner, that they may be extended and inflated by the imbibed humour, all which happens gradually; in the mean time the head, which inſenſibly and in a manner ſcarce to be perceived, recedes or goes back from the skull, is gently extended and expanded; this is principally occaſioned by the eyes and their adjacent parts being inflated or diſtended with air, blood, and other fluids ruſhing in; the thorax likewiſe now becomes extuberant, by reaſon of the air and fluids introduced; as do alſo the legs themſelves in like manner ſwelling conſiderably both above and under the thorax; they are placed in a very elegant manner under the skin: the firſt or foremoſt pair of legs adhere underneath near the proboſcis, which together with all its parts is ſtretched upwards, to the head in ſuch a manner, that the extreme ends are in the upper part, and the thighs in the lower place; then follows the ſecond pair of legs which are depoſited in like manner; near theſe the wings are ſituated, whereof the leſs are placed by the ſides of the greater and a little under them; then follows the laſt pair of legs, which is depoſited in the ſame manner as the firſt and ſecond were under the ſkin; all theſe parts, as far as they lie under the ſkin, are ſomewhat wrinkled or folded, and they are by this means above one half ſhorter than afterwards when the creature is changed into a perfect Nymph; for when the Worm caſts it ſkin, theſe parts are conſiderably and wonderfully inflated and extended by force of the air, the fluids, and particularly of the blood: this extenſion of theſe parts is performed at the time when the Worm, by the means of a kind of periſtaltic motion, breaks open the ſkin by rolling it down, and is incredibly promoted by the parting exuvia or caſt ſkin; for ſince all theſe parts by means of delicate and minute fibres and filaments adhere looſely to the ſkin; hence the ſkin carries them with it as a kind of moveable cords, and the parts themſelves being by this means extended, roll in their turns from the ſkin in the ſame manner as a cord runs out of its pully. This is the true reaſon why theſe parts are ſo regularly digeſted and extended in the Nymph, and are diſpoſed in ſo beautiful and firm an order and ſo wonderful a ſituation as I am now going to deſcribe, according to the figures which I have given. I ſhall firſt then ſhew in a ſomewhat ſmaller figure the diſpoſition of the parts under the ſkin, a little removed from their firſt ſituation. Tab. XXV. fig. IV. *a a*, are the horns, *b* the proboſcis with its parts, *e e* denotes the firſt pair of legs, under which is ſeen a ſecond *f f*, and then a third *g g*; *h h*, *i i* are the larger and ſmaller wings of each ſide: *k* denotes the rings of the abdomen. I ſhall in the ninth figure repreſent the ſituation of theſe parts in the Nymph in a larger ſcale.

Fig. IX. *a* Repreſents the Nymph's head, which being then diſtended with humours, and expanded by force of the impelled air, reſembles in ſoftneſs and tenderneſs, milk that is juſt curdled. In this manner the whole body and all the reſt of the parts are circumſtanced at this period. All theſe parts are of a milk-white colour, and the whole inſect is without any the leaſt viſible motion; ſo that in reality, it reſembles a dead carcaſe.

b b Exhibit the eyes of the Worm, which now appears under the form of a Nymph. Its three ſmaller diſperſed eyes cannot be ſeen in this view, being placed more backward and higher in the head, in the middle between the larger eyes. The firſt change obſervable in this creature, when it becomes ſtronger by the evaporation of the moiſture is manifeſted about thoſe ſmaller eyes, and about the large ones here figured *b b*. Their change conſiſts in this, that the eyes, by degrees and as it were, inſenſibly aſſume a faint purpliſh colour: at the ſame time is alſo diſcovered the ſemi-lunar figure of theſe large eyes, which one cannot otherwiſe diſcern, on account of the intenſe whiteneſs which obtains here, and the brightneſs of the ſurface.

c c Are the antennæ or horns which ſpring from the middle of the head, and are bent by force of the ſkin that is drawn down towards the belly; they are very elegantly placed near the proboſcis and its adjacent parts. Under the extreme ends of the horns are diſpoſed the three firſt joints of the firſt pair of legs *i i*. In the middle of theſe one may ſee numerous pulmonary tubes through the covering.

d Denotes the lip, which is not yet remarkably increaſed in its ſize, or diſtended.

e e Are the teeth or jaws, which are covered in ſome meaſure by the lip.

f f Shews the firſt pair of thoſe parts which belong to the trunk or proboſcis: they have likewiſe their pulmonary tubes, but above them and under the teeth is ſeen a certain portion of the third or laſt pair of theſe little parts belonging to the trunk, which are the ſhorteſt and ſmalleſt of all.

g g Repreſent the articulated pair of little parts that defend the proboſcis, which are divided on each ſide into three joints.

h Is the proboſcis itſelf, very beautifully ſituated between and under the ſaid parts. But we muſt obſerve, that all theſe little parts are now furniſhed with tranſparent pulmonary tubes. When the little inſect is approaching to its laſt change, and is in a ſhort time after to obtain the form and name of a Bee, then all theſe pulmonary tubes become again for the moſt part inviſible. And the ſame thing obtains about the veſſels of the wings: which are then bound or tied up in ſuch a manner, that you would conclude them not to be pulmonary tubes but nervous fibres.

i i Exhibits the firſt pair of legs in the Bee, while it is ſtill called a Nymph. The three extreme joints of theſe legs may be ſeen under the extremities of the antennæ *c c*.

k k Are two very beautiful, ſtiff, tranſlucent little parts, ſituated at the loweſt joints of the firſt pair of legs, and which ſeem to ſerve the Nymph only as an ornament; for upon caſting the ſkin, they are thrown off and entirely aboliſhed.

l l Another pair of the Nymph's legs, which likewiſe are full of tranſparent pulmonary tubes. Theſe legs, being, by means of the ſkin when drawn off, and by the power of the impelled air and forced humour, depreſſed and ſtretched beyond the middle of the body, are there very regularly placed.

m m Are the wings of the Bee, ſtill conſtituted under the form of a Nymph, a part of which only we can hitherto ſee. Theſe likewiſe have many pulmonary tubes, which, when this Nymph is caſting its laſt ſkin, are alſo, together with all the other parts, once more to throw off their exuviæ: after which, when theſe tubes are again diſtended by the freſhly impelled air, and the pneumatic veſſels which have been hitherto contracted, are inflated and diſtended with the ſame air; it follows, that the whole wing afterwards expands itſelf and becomes thrice, nay, four times larger than it was before. But this expanſion of the wings is not to be attributed ſolely to the air, but in a conſiderable degree alſo to the blood; for at the time when the air is impelled into the wings, and a conſiderable quantity of blood is likewiſe driven into the blood veſſels of the wings. This blood in the Bee is a limpid humour or ichor, as may be obſerved, if a little part be at this time cut off from the wings; for then this humour flows from it, appearing by reaſon of the extreme ſmallneſs of the blood veſſels, under the form of little pellucid globules, which, inſenſibly and by degrees, increaſe into conſiderable little drops. We muſt obſerve here, that ſome of the Nymphs of Flies, when they are caſting their skin, not only expand their complicated wings, but alſo diſtend vaſtly their whole body: hence it ariſes that they appear twice as big as the exurvæ, wherein they were before encloſed. The expanſion of the wings in Butterflies is the moſt elegant of all the phenomena of this kind that occur in nature; for in theſe creatures, the wing in the ſpace of a quarter of an hour, though at firſt not bigger than half the nail of one's little finger, becomes as broad as a half crown, and at the ſame time all its colours are augmented, extended, and regularly diffuſed: and hence indeed, an admirable ſight is produced, which would appear the more wonderful if one had but the leaſt knowledge of the cauſe of it. For we certainly can know nothing of the magnificence of nature's ſecrets, unleſs by the help of an infirm and weak reaſoning we are able to paſs our judgment on the more evident and palpable effects; but even this is ſubject to many errors. When the wings are diſplayed in the Butterfly, their air-pipes or pulmonary tubes are ſoft like warm wax, and the wings hang down that they may the more eaſily be diſtended with air and humours.

Tab. XXV. fig. IX. *n n* Are the ſcapulæ or ſhoulder blades of the Bees Nymphs, which are ſomewhat ſharper a little lower. Under theſe are ſeen a pair of orifices, by which the air-pipes open into the breaſt. The air which is expelled through theſe orifices aſſiſts in producing the humming noiſe which the Bees make with their wings.

o o Exhibits the laſt pair of legs, which are likewiſe furniſhed with tranſparent air-pipes like little veins.

p p Are the rings of the abdomen, in which ſeven apertures of air-pipes open on each ſide. But I have not delineated theſe apertures in the preſent figure; ſince I do not yet know their true ſituation, for they appear very obſcure, becauſe only one colour is ſeen here. However, I have obſerved in diſſecting the Nymph, that the mouths of theſe air-pipes terminate in the rings of the abdomen. I have ſeen alſo three ſuch orifices in the breaſt. I ſhall now mention ſome other things in the anatomy of the Nymph, which are pertinent to this matter.

q Exhibits the hinder or poſterior parts of the Nymph. The ſting of the future Bee is ſeen there ſomewhat protuberant out of the body, as are alſo thoſe two little parts *r*, which accompany the ſting in the common Bee and in the female. And laſtly, the arms appear underneath *s*.

If all theſe parts be afterwards removed out of their places, then the diviſions of the head, breaſt and abdomen appear very beautifully in the Nymph, but moſt particularly thoſe of the breaſt: and thus we may at the ſame time beautifully ſee how the legs are jointed with the breaſt, which cannot be diſtinctly ſeen in the Bee ſtate of this little inſect, on account of the great quantity of down riſing there. If the creature be then inverted ſo as to lie on its belly, the three great diviſions of the body are manifeſtly ſeen in it: and in the horny or bony parts of the thorax, which are ſtill membranous, and very tender numerous air-pipes are likewiſe obſerved.

The firſt external change obſervable about the Nymph conſiſts in this, that its eyes inſenſibly become of various hues. Firſt of all are diſtinguiſhed thoſe three remarkable ſeparate eyes, which, when the inſect lies on its back, are ſeen fixed between the ſemi-lunar curvatures of the larger eyes, as I ſhall hereafter explain more at large. And at the ſame time, the ſemi-lunar figure of the eyes is conſpicuous by their variety of colours. Nor can any other remarkable change be obſerved at that time in the Nymph, beſides this of colour, which occurs in the three ſeparate and in the ſemi-lunar little eyes.

When the eyes by degrees have grown purpliſh, then ſome ſmall changes are likewiſe ſeen about the body and legs; that is the horny or bony parts of the ſhoulder blades begin to acquire a yellowiſh tinge, ſomewhat inclining to a brown red: the horny or bony parts of the wings, legs, and the reſt, then afford alſo ſome ſmall ſigns of their transformation.

Whilſt the colour of the limbs and parts is changing in the manner I have mentioned under their accretion, the purple colour of the five eyes become more and more brown, and at the ſame time we obſerve, that the claws of the feet become alſo horny or bony, and of a brown red: and this change is alſo obſerved about the teeth.

In the mean time the eyes become, by little and little, more blackiſh, nor is there yet any diviſion in the coat that inveſts them on the outſide, though one may then eaſily ſee the diviſions which appear through the coat. The horny or bony parts of the trunk now alſo begin to grow black, and the horns, which are ſituated under the eyes, and the diſtinct eyes above are more plainly ſeen.

The thorax alſo is about this time from a gray, manifeſtly changed into a browniſh colour: and we alſo ſee the whole body under the skin, diſtinguiſhed by ſome blackiſh ſome blackiſh points, which are the rudiments of feather-like hairs.

Whilſt the whole body is changing in this manner, it is altered or diſguiſed, and becomes more robuſt as it is increaſing; ſo that even the claws of the feet now evidently move within the skin wherewith they are ſurrounded; but the moſt remarkable changes are obſerved about the ſting. For this ſting is hitherto an external part, though it may afterwards be, and actually is drawn back into the body: therefore, ſince it is conſpicuous in the Nymph without any previous diſſection, one may eaſily obſerve its increaſe and perfect formation. The better to underſtand my obſervations on this part, I think it neceſſary to obſerve before-hand that the ſting, as well as all other parts of the body, changes its skin when the Nymph throws off the laſt exuviæ: for this reaſon, the changes of the ſting may be diſtinguiſhed as clearly as thoſe that happen in the claws, legs, and the teeth. The firſt change, therefore, which is obſerved about the ſting, conſiſts in this, that its crooked little hooks, which neceſſarily remain fixed in the wound given by the ſting of a Bee, come in ſight. For while the two ſide-pieces, and the caſe or ſheath of the ſting are yet membranaceous, or as it were cartilaginous, theſe little hooks are diſtinguiſhed by their yellowiſh red colour; and this colour is afterwards diffuſed by degrees through the whole ſting, whilſt in the mean time the ſharp-pointed ends of the two ſide-pieces of the ſting, are acquiring a horny or bony ſubſtance, and more dusky colour. The circuit alſo, or extremity of the caſe or ſheath of the ſting, in like manner changes its colour, grows hard, and becomes horn-bony. And as the other parts ſtill retain their white colour, the ſaid changes ſtrike the eyes the more plainly: for we muſt obſerve that the ſting is, with regard to its colour, more conſpicuous in the Nymph, than it is afterwards in the Bee itſelf. Moreover, the two ſide-pieces, as well as the ſheath of the aculeus, are encloſed in peculiar membranes, which are thrown off in a moſt ſingular manner: hence one may very diſtinctly ſee theſe ſide-pieces in the Nymph placed near each other, which is by no means the caſe in the Bee; ſince theſe parts of the ſting in that ſtate of the inſect are hidden in the caſe or ſheath, as I ſhall hereafter deſcribe at large, and repreſent in figures. About this time, alſo, theſe ſeveral parts, as well as all others, acquire each their laſt perfection; that is, the eyes, teeth, legs, claws, horns and the reſt: nay, the thorax itſelf inſenſibly becomes during this time more brown, and approaches nearer to a horny nature, and grows very ſhaggy with ſtrong hairs.

The laſt change happens in regard to the ſtrength and colour of the wings: at the ſame alſo the proboſcis or trunk in like manner preſents itſelf to view in its ruddy or bright brown colour, and ſhews the hairs wherewith it is adorned. Thus all the ſuperfluous humidity of the Nymph being at length evaporated, it caſts a skin from all its parts, and after gnawing a paſſage through the web, creeps forth at length from its cell, in which it had hitherto lain, in its perfect form of a Bee. The wings indeed are at that time uſually complicated or folded up, and yet I ſometimes have ſeen them expanded; that is, when it hath been for ſome time detained in its waxen habitation, and hath not been able to creep out of it with ſufficient ſpeed: in that caſe we find that its wings have been firſt diſplayed within the little cell: all the ſpecies of Flies appear in like manner, when freſh from the Nymph, with complicated wings.

When I diſſected the Nymph of the common Bee, at the time that its colour juſt began to be viſible, upon opening the outer skin, I obſerved the fat ſeparated very eaſily from the air-pipes or pulmonary tubes; which was likewiſe the caſe about the outmoſt coat of the eyes, which has no diviſions. All the contents of the eye alſo were very ſoft. The inverted pyramidal fibres hereafter to be deſcribed, reſembled jelly made of veal. The brain was likewiſe ſo ſoft that being only very lightly touched, it immediately ſeparated from the beginning of the ſpinal marrow. The ſpinal marrow itſelf was there as well as in the body very ſoft and tender. Nay, and the three ſeparate little eyes, which, as ſhall be made more evident hereafter, are placed in a triangular form between the divided eyes, after I had taken off the skin from them, and can be diſtinguiſhed very clearly. The teeth were as yet membranaceous, nor did they ſhew any ſign of hardneſs, or of their being of a horny or bony nature; they abounded within with a mucous humour, upon preſſing out which they ſeemed hollow. The jaws in human abortions ſix months old, likewiſe ſhew membranaceous teeth, which however in various places are obſerved to be growing into bone.

In the thorax all things are at this time amazingly ſoft and tender. The muſcular fibres may be ſeen very diſtinctly, and in ſome meaſure as if ſeparated from each other; but they are ſtill ſo exceſſively delicate, that being but very gently touched, they immediately quit the place where they were fixed: moreover, they are at this time ſhorter than in the ſame inſect when it is changed into a Bee. Indeed, I obſerve that all theſe muſcular fibres are at firſt contracted in the ſame manner by nature, and that in ſpite of her, as it were, they are afterwards extended by the blood and humours. This is probably the reaſon why theſe fibres endeavour to contract themſelves continually, and that even a long time after the death of the creature. This ſhortneſs of the muſcles in creatures not yet brought forth, is occaſioned by the inveſting membranes binding up their bodies; and hence it happens that the blood and air are prevented from diſtending the muſcles ſufficiently. We have before mentioned ſome ſingular and obvious examples of this matter in inſects, which are ſeen as ſoon as thoſe creatures come into the open air. The fat alſo very eaſily in this diſſection of the Nymph quitted its connecting membranes and the pulmonary tubes, and, by its friability, preſently hid the other parts from ſight, for it divided and diffuſed or ſpread itſelf into innumerable white parts of different bigneſs. Between this fat were likewiſe ſeen the pneumatic veſſels, not much changed from that appearance which they had before in the Worm, when it was about to caſt its skin.

The ſtomach in this Nymph appeared ſtill ſomewhat long, for it had not wholly contracted or drawn up the length which it has in the Worm, into the pyriform figure which it wears in the Bee. All the reſt of the viſcera of the body were already formed and conſiderably increaſed. The inteſtines were very elegantly conſpicuous, and of moderate ſtrength, but they were filled with watery contents, nor did they yet contain that green ſubſtance, which is to be found in the inteſtines of the more mature Nymphs, and thereof the green colour is evidently ſeen through the body and heart in the back. The ſame thing obtains in calves whilſt ſtill in the cow's belly, and the contents of the inteſtines in them in like manner change colour. It is alſo very remarkable here, that ſuch hairs are found intermixed with thoſe excrements, as the mouth and body of the calf is covered with; and this argument moſt evidently demonſtrates, as I have obſerved before, that theſe animals convey the food while in the uterus through the mouth; nay, and take in the hairs which they licked off the ſurface of their body, together with the fluid of the amnion. The vaſa crocea, or yellow veſſels alſo may be very eaſily diſtinguiſhed in this Nymph, and ſeparated eaſier from the inteſtine, than in the Bee arrived to its full maturity; for, beſides the friability of the fat, the membranes are yet very tender, and the pulmonary tubes, to which theſe veſſels are connected, are very weak. The internal parts of the ſting alſo, which are not viſible on the outſide, may be now very plainly diſtinguiſhed. It was further admirable to ſee in this diſſection the aculeus or ſting, which afterwards becomes ſo ſharp-pointed, hard and formidable for wounding, is ſtill very ſoft and tender, like a thin membrane, and is likewiſe filled with an aqueous humour, which naturally flows out of it. The poiſon bag * of the ſting was contracted, and its cloſed tubes, by the help of which the poiſon is ſecreted and conveyed into the bag, may now alſo be diſcerned.

But as all the parts hitherto mentioned were extremely ſoft and yielding at the time of this diſſection, ſo, on the other hand, the productions of the wind-pipe, or little pulmonary tubes, preſented themſelves more diſtinctly to the view. The reaſon of this, as I have before obſerved, is certainly that the fat and the membranes which connect it, recede from theſe parts with the utmoſt eaſe: we lay open the Nymph from the bottom quite to the top with a ſmall pair of ſharp-pointed ſciſſors, all the fat, the little membranes and the reſt of the contents may be without any difficulty, in a baſon filled with water waſhed out ſo thoroughly, that the pulmonary tubes alone, though they indeed, with reſpect to their larger branches, are not removed from their natural ſituation, ſhall remain behind in the skin. The ſame experiment may alſo be made in another manner, viz. a fine glaſs tube may be thruſt into the body of the Nymph, and by the help of water injected through it, all the contents, except the tubes that convey the air, may be waſhed out of the body. This may likewiſe be done alſo in the Worm, when it is on the point of changing its skin, and then being blown up with air it may be dried and preſerved. The ſame experiment may be made with the utmoſt eaſe in the melts of oxen; for if you waſh off the outermoſt ſubſtance of the melt through the vein, and then cut away with a fine knife the exterior coats from the melt when dried, you will have a moſt curious preparation. At this time we have a moſt beautiful view of the pulmonary tubes, and their ramifications in the Nymph of the Bee; ſo that they may with very little trouble be counted and diſtinguiſhed from one another; ſeven appearing plainly in the belly, and three in the breaſt on each ſide. The firſt pair of theſe open with fair apertures on the outſide in the breaſt near the neck; but before theſe two tubes aſcend from thence towards the head, having firſt taken a wider circuit, they join together, and then in two very diſtinct branches, like the carotid arteries in man, they again aſcend towards the head, inſerting themſelves in the brain, the eyes, the horns, and the teeth. The next two orifices are opened under the ſhoulder-blades, and the laſt under the wings. Some branches likewiſe, and thoſe very diſcernible, run different ways out of the breaſt towards the legs and wings; and theſe at the laſt changing of the skin aſſiſt greatly in the unfolding of theſe parts, as I have already obſerved. In the belly I could not ſo accurately diſtinguiſh the orifices of the pulmonary tubes on the outſide, for there they ſeem to be inſerted obliquely, like the urinary paſſages in men and quadrupedes. But however, in the inſide of the body their inſertions are extremely obvious: this may be ſeen alſo even on the outſide, if we free the Nymph from its coat or ſtrip off its skin with due skill, and then draw the air-pipes out of their orifices. As for the poſition of theſe pipes in the body, I have already ſpoken of it elſewhere, and ſhall explain it farther in a ſucceeding chapter.

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* The poiſon of the Bee ſeems to owe its miſchievous efficacy to certain pungent ſalts. It may be eaſily ſeen to contain ſuch. Let a Bee be provoked to ſtrike its ſting againſt a plate of glaſs, and there will be a drop of the poiſon diſcharged and left upon the glaſs. This is to be placed under a double microſcope, and as the liquor evaporates the ſalts will concrete. They form oblong, pointed, clear cryſtals, but the quantity of fluid is not enough to let them form diſtinctly.

The Nymphs of Bees, after they have continued ſhut up in their little waxen cells for a ſufficient time, and till the entire evaporation of the redundant moiſture, ſhed at length their laſt ſkin of all, which accordingly is found in the bottom of the cell, together with the former, which they have thrown off during their exiſtence under the form of a Worm. Having thus caſt their coats, they then break their web, by the aſſiſtance of their teeth, and at the ſame time forcing their way through the wax that is faſtened down above to the web, and burſting it into ſeveral jagged pieces, they throw it off on all ſides; after this other Bees carry theſe broken pieces away, and clear the cells ſo thoroughly, as to make them quite ſmooth and even. The male, as well as the female Bees, force their way alſo out of their cells, in the ſame manner as the common or working kind, and all undergo the ſame change. This remarkable difference, however, is to be obſerved, that the common Bees, and of the male kind alſo, uſually come forth, as already obſerved, with their wings then folded up; ſo that after they have burſt through their webs, their wings remain yet to be expanded, by the force of air and humours impelled within; for, as has been already obſerved elſewhere, thoſe large veſſels, which are perceived in their wings, after the manner exhibited in Tab. XXV. fig. x. are without doubt the tubes that convey the air. Cloſe to them alſo are placed the blood veſſels, which bring the nutriment to the wings. This obſervation I have made is highly worthy of notice, ſince it moſt evidently diſplays the wonders of God, in the inſect world, and at the ſame time utterly overthrows thoſe impious notions, that theſe creature are generated from putrefied matter, and by a certain fortuitous concourſe of particles; for if we grant that, the eſpouſers of theſe notions take occaſion thence moſt perverſely to carry on the argument to large animals, and in a moſt offenſive and indecent manner leſſen and detract from the providence and omnipotence of God, which are univerſally and equally manifeſted in every ſpecies of animals without exception. In truth, if the moſt minute creature is capable of being generated from putrefaction, nothing hinders but that the largeſt of all may likewiſe.

The female Bees do not, as the common Bees and the male, come forth with their wings folded up, but expanded and diſplayed: they come out of their cells in a ſtate of flying. On this account, the all-wiſe Author of nature has provided for them a more ſpacious manſion, in which they may expand their wings conveniently and properly, ſo that after they have burſt from their cells, they may be prepared for ſwarming immediately, if there be a neceſſity for it, or that the young female may be in a condition to drive out even the mother Bee herſelf, that is the old female, and to take her place, if there be occaſion.

I am fully perſuaded that the reſt of the Bees know beforehand, by ſome ſure ſign, when the new female is employed in breaking through her cell; and, accordingly for ſome days before they form a new colony or ſwarm, we ſee a great many Bees hanging about her cell, which are no doubt waiting for the female's iſſuing forth, and when ſhe is juſt on the point of coming out, they make a buzzing with their wings, which is the ſong of Bees, receive and ſalute her at a diſtance as it were with marks of joy. I make no doubt but that the males are moſt concerned in this buſineſs; not unlike wanton horſes, who, when they ſee the mares, though at a diſtance, neigh after them, and inſtantly prepare themſelves for leaping. This is the caſe likewiſe in the males of Silk-worms, which, before they ſo much as ſee the female, yet immediately, as ſoon as they get the ſcent of her, by the help of their wings ſet up an agreeable humming; and ſo irritated are they with a burning deſire for copulation, that they will frequently copulate with the females even when dead, nor can they without force be torn off. However, I do not believe, that the male Bees actually copulate with the female, though indeed they love to get as cloſe to her as they can, becauſe thus they feel a titillation ariſing from the emiſſion of their ſperm. For I am firmly perſuaded, that the male Bees eject their ſperm in the ſame manner as Fiſhes, who only ſhed it upon the ſpawn, nor have any thing further to do with the females. It would be no difficult matter to make certain experiments, in all theſe particulars; as to try for inſtance whether the female Bee, encloſed in a little net made of fine thread, or in a ſmall glaſs veſſel covered with a piece of fine linen, or in a box with holes in it, could be impregnated by the bare ſcent of the male. But of all theſe things I ſhall hereafter treat more at large. I think it neceſſary, however, to add this ſingle obſervation, that the laſt humming or noiſe which is heard in the hive, a little while before the Bees are going out to ſwarm, is raiſed by the female Bee alone, ariſing to be ſure from her joy in feeling herſelf then impregnated, and being ſenſible that ſhe is ſoon to make an excurſion; ſince the ſound, which is then heard, is owing only to one Bee, and that no other than the new queen.

I once found a female turned quite upſide down in her cell, and yet perfectly formed with her wings already expanded for flight. She had been attempting a paſſage on the oppoſite ſide of her cell, endeavouring to break through the middle wall of the comb itſelf, great part whereof ſhe had already eaten through: ſhe ſeemed as if ſhe would be able to get out of the cell in a few days. In theſe difficulties I came to her aſſiſtance, and at the ſame time got myſelf a proper ſubject for diſſection. When the Bees begin to perceive that the female is near coming out of her cell, I make no doubt but there muſt ariſe a very remarkable commotion in the hive, as well amongſt the younger as the older Bees; for the young follow the new-born female, and the others remain with the elder; nay, many both old and young hang together idly round the ſame female. This diviſion into parties is not owing either to choice, or any ruling power or authority among the Bees, nor is it performed with thoſe fancied ceremonies of honour, and a numerous retinue of old and venerable Bees ranged in order, accompanied with the harmonious ſounds of trumpeters, hautboys, and muſicians, or in the tremendous preſence of executioners ſtanding around, as authors have feigned, ingeniouſly indeed, but derogatory to nature. Nothing like this is the caſe: there is doubtleſs implanted in them a concern for breeding up their young, which inſtinct makes the Bees flock in this manner round the female: nor have the tribe of ſlaves, I mean the working Bees, any other task aſſigned them, as they are capable of being moved by that incentive only, and direct all their actions to that end, though in truth the labour is very great, which they muſt undergo in breeding up the young, and continually building the cells deſtined for them. However they are amply repaid, ſince in their turn, in place of a rich reward, they feed on delicious honey, which they collect with indefatigable diligence; for nature, in this their wretched ſtate of life, makes every thing to be purchaſed with labour. I could wiſh therefore that this example had the weight it deſerves, in inſtructing and teaching us that God might be glorified in all his works.

Were the working Bees furniſhed with the organs of generation, or any thing analogous to them, we might conclude, not without probability, from their actions, that they were actuated with the moſt ardent luſt to the act of generation, and ſolely by this incentive animated to perform the ſeveral tasks aſſigned them. But ſince they are ſupplied with none of the parts requiſite for that office, they can have nothing elſe in them, but an innate deſire for the propagation of their ſpecies, which inflames them with ſo earneſt a concern for breeding up the young, and with ſo ſingular an affection towards the female, the common parent of all. This will appear evidently, if you take this queen out of the hive, and tie her to the end of a ſtick, by a thread run through one of her wings, and then ſuffer the ſwarm of Bees to fly about her; for they, following the queen cloſely, will all of them by degrees ſettle on the ſtick, and by the help of their legs cling to one another moſt ſurpriſingly, ſo that they reſemble, as it were, a complete bunch of grapes. When they are piled up together after this manner, they will ſuffer themſelves quietly to be carried up and down over a whole garden, nor do the working Bees in the mean while ſtir from their queen, as I myſelf found by a careful experiment I made. If at this time any other Bees fly up to this numerous cluſter, an obſerver will ſee plainly, that they immediately ſearch after the queen with ſuch anxiety, that even from hence ſufficiently appears the prodigious affection they have for her, and for the propagation of their ſpecies; for they endeavour to make their way through the middle of the bunch, as it were, that they may reach the female. In a little time afterwards they give over their attempt, and then, without intermiſſion, continue flying from and back again to the cluſter. From theſe obſervations therefore it is altogether manifeſt, that the actions of Bees of the three kinds, male, female, and eunuchs, ſpring from no other cauſe, but from a vehement and ardent concern, by which they are carried to the generation, preſervation, and raiſing of the brood, which, as it is alone the principle, ſo likewiſe is it the end of every thing the Bees do. If after this the female be looſed again from the ſtick, and immediately put into a drinking glaſs, placed on the ground, or on a piece of tile, the reſt of the Bees, to a ſingle one, will inſtantly ſurround her again, and beſet the place where ſhe is in ſuch throngs, that one can ſee nothing but Bees covering it on every ſide. From all this I think it may be inferred, not without an appearance of truth, that the female emits a very ſtrong ſcent, by which the reſt of the Bees are attracted to her. I obſerved this moſt evidently when I had ſhaken the ſtick, and had laid the female in the manner abovementioned on a table, in an open arbour, at ſome diſtance from them. For this reaſon I formerly, before I was acquainted with the true ſtructure of the common Bees, compared them to a parcel of Dogs, which follow the female in her time of luſt, excited by the bare ſcent; however, I will not deny, but that there may perhaps be ſomething elſe beſides the ſcent in this affection of the common Bees, by which they are ſo greatly affected: they ſeem to imitate in ſome manner creatures that have been gelt, which, though they can do nothing, are notwithſtanding inflamed with a prodigious luſt for the female.

As therefore it is generation alone by which the Bees are excited to all their actions, ſo this great cauſe, whenever it happens to be interrupted, is the ſole motive from whence all the confuſion at times obſerved in the hives ariſes. If the female Bee be barren, or maimed, crippled, blind, or deprived of its wings, neither honey nor wax will be collected, nor will the eggs be laid in the cells. There is in this caſe no occaſion for building cells for rearing up the brood. But if the female be properly perfect, every thing is done in due order, and as the poet ſays,

> " While the ſovereign is ſafe, all live in
> " perfect harmony." Virg.

A great diſturbance is alſo to be obſerved, whenever there chance to be two females in one hive, and one after another lays its egg in the ſame cell, for from thence ariſes not only a vaſt confuſion about the article of raiſing the young, but a mighty inconvenience likewiſe about the building of the cells. It ſhould be here conſidered further, that Bees, for two neceſſary reaſons, namely, the building of the cells, and the rearing of the Worms in them, attend, and of neceſſity muſt attend, the female, at all times and every where; for if ſhe has by chance depoſited her eggs in an imperfect cell, the reſt of the Bees are obliged, by virtue of their office as it were implanted by nature, immediately to make it complete, that the worm to be hatched may have room wherein to move itſelf, to eat, to change its skin, and to ſpin its thread: whenever therefore, which I would have obſerved particularly, the two females, each with her retinue, meet one another, and the Bees are hindered by it in their attendance and work, is it not eaſy to be imagined, there muſt ariſe a prodigious confuſion? where is the wonder then that they burn with fury, and, urged by love to their offspring, violently attack one another, determined upon killing and deſtroying one or the other female? This is falſely aſcribed by authors to the divided government of two fancied kings, as if they could not live together with a joint power; but this is an idle tale: all this fighting is cauſed ſolely by the propagation being hindered: take away this impediment, and the two females will live very amicably together; for as they have not the uſe of reaſon, they are unacquainted with Virgils maxim, that a kingdom does not admit of two rulers *;

> “ For two pretenders oft for empire ſtrive.”
> DRYDEN's Virg.

That this matter may the more eaſily be underſtood, I ſhall inſert here a rude kind of a ſimilitude. The republick of the Bees may be compared in ſome meaſure to a houſe compriſing five thouſand bed chambers, in which there is only one woman, who yearly by the ſcent of the ſperm in ſome hundreds of men born within this houſe, and living in it for the ſpace of ſome weeks, is impregnated with a triple brood. Suppoſe there were beſide in the ſame houſe ſome thouſands of natural eunuchs, or virgins, who, employing themſelves in the finiſhing of the chambers, and ſtaying in the paſſages between the ſaid bed-chambers, conſtantly attend that woman, that they may ſee in which chamber ſhe firſt brings forth a girl, a boy, or an eunuch; let theſe maids or eunuchs take care of and nouriſh this child that is born, as likewiſe all the reſt of them, which that ſingle woman afterwards in order, by going into each of the bed-chambers, is yet to be delivered of, and let the bed-chambers not be a whit larger than may be able juſt to contain the children, till they have arrived at their maturity. Theſe circumſtances being rightly underſtood, it is eaſily to be imagined what a horrid confuſion and diſcord would ariſe, were another woman likewiſe to get into this houſe, and the body of the eunuchs being divided into oppoſite parties, to fight againſt the former woman and her attendants, reſolutely ſtriving to lay yet another child in any of thoſe ſmall bed-chambers. Muſt not thus the ſettled order of the oeconomy be neceſſarily ſubverted? and muſt not all the inconveniencies and broils that can be imagined inevitably ariſe?

Behold! this is the true ſtate of the Bees government. It may be proper to take notice alſo of this ſingle particular, that in this houſe yearly by that one woman alone are brought forth three or four younger females, ſome hundreds of males, and ſome thouſands of eunuchs; and that then ſome thouſands of theſe new-born eunuchs and males together, join themſelves either to the elder female, or to the firſt-born of thoſe four younger ones, and having left their original houſe, they build a new one ſolely for their own habitation; but at laſt that theſe eunuchs kill all the males, as ſoon as the female, who came out with themſelves, is impregnated by the ſcent of their ſperm, and after that they live with the female alone for the ſpace of an entire year. If all theſe things are rightly applied to the republic of the Bees, it will be no longer difficult to aſſign a reaſon for every action of the Bees, whatever it be, ſuch as their building, raiſing their offspring, collecting of honey, and all the reſt.

From what has been here ſaid, it evidently appears, that one female, and only one, is neceſſary to, or can be ſuffered to ſubſiſt in one hive; therefore a hive that has no female in it, if it be provided with a due number of eggs, will continue in a better ſtate, than if two or more females dwelt in it; for in that caſe, one female innocently ſubverts and diſturbs the whole order, whilſt the other with her working Bees is labouring to perform the great buſineſs of producing and rearing the young, and building cells for them. I cannot but praiſe on this occaſion the wiſdom and circumſpection implanted in the Bees, that they on this occaſion always kill one of the females, but preſerve the other in ſafety; for without doubt it has appeared beſt to all-wiſe nature, that one female ſhould periſh, rather than that both of them, together with the hive, the eggs, the Worms, the Nymphs, and the reſt of the Bees, be involved in an univerſal ruin, ſince all this muſt neceſſarily be the conſequence of ſuch a diſturbance.

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* Nothing is leſs underſtood in the hiſtory of the Bees, than thoſe battles we ſee often about the entrances of their hives. From what I have obſerved they appear to be of two kinds; ſometimes between the Bees of the ſame ſwarm; ſometimes between them and ſtrangers: any irregularity in their work may occaſion their ſcuffles with one another, and theſe terminate without miſchief. But in the other caſe, when ſtrange Bees attempt to force their way into the hive, the conflict is fatal, and there are uſually many killed; but the ſuperior number always gives the victory to the proper poſſeſſors of the hive.

But as nature, all-powerful in herſelf, is tied down by no laws, in other neſts of inſects, and even in different ſpecies of Bees, a different order and other regulations have place. This is manifeſt in Hornets and Waſps; for theſe inſects ſuffer many females at once in the neſt. It is proper to obſerve here this remarkable difference, that each of theſe females lay only a few eggs, and that they fly abroad together with the males to catch leſs inſects; with which, after the manner of ſparrows, they feed their young; for of them only two kinds, namely the male and the female, live in one houſe: whether among theſe inſects the male too, on account of getting food for the young, flies abroad, and ſo is not, like the males among the Bees, exempted from labour, I have not hitherto obſerved; though I make no doubt but that the male likewiſe contributes its help towards bringing up the young; for though Hornets are much fewer in number than Bees, they have ſometimes no leſs than 1500 young to rear at once. In a Waſp's neſt, which I keep by me, there are more numerous cells than theſe, and I found an infinite number as it were of young ones, eggs, and Nymphs in it. This male Hornet, like the male Bee, has no ſting. From theſe examples it is manifeſt, what wonders are diſplayed to our eyes in inſects, and with what ardency the ſearching into them ſhould influence us to magnify the glory of God: "For he doeth great things "paſt finding out; yea, and wonders without "number." Job. ix.

That the office of rearing up the Worms, or the young brood of the Bees, is really intruſted to the common or working Bees alone, and that all their care, and every thing they do, is directed to that end, this ſignal obſervation ſhews plainly, which was communicated to me by a certain breeder of Bees yet living, who is thoroughly skilled in the management of them. He told me, that by a certain and infallible method, a prodigious number of females, vulgarly called kings, might be procreated, and that from hence, in the ſpace of one year, three or four times more ſwarms might be obtained, than otherwiſe is uſual in our cold climate. It is done in this manner, viz. in the month of April, when on inverting a hive you ſhall find ſome eggs or Worms in the peculiar cells deſtined for the females, take out the elder female, together with ſome few Bees, and put them into another hive apart; theſe will ſettle in this new place, build their cells, lay their eggs, and raiſe up a progeny: then ſometime afterwards look again into the firſt hive, and if you find there a female newly come our, ſprung from the egg left before in the hive, take this likewiſe in the manner mentioned above, out from thence, and, in company with ſome other Bees, put her into a hive of her own, that ſhe may bring forth there. If in the ſame manner you ſhall manage afterwards the reſt of the females, which ſhall be one after another produced from the eggs depoſited in the firſt hive, in the ſpace of one fruitful ſummer, from a ſingle hive, you will thus be able to get ten, nay, ſometimes fourteen females, each together with a ſtock of Bees, their ſubjects as it were, that is ſo many ſwarms. It muſt be obſerved that this can only be done in a fruitful year, for at other times the Bees not only will not multiply faſt enough, but they will not be able to provide a quantity of wax and honey to ſubſiſt themſelves during the winter: care muſt alſo be taken to prevent that firſt hive from ſwarming, ſince each female, which with its working Bees is taken out from thence in the manner here mentioned, ſhould be looked upon as conſtituting a ſeparate ſwarm. I ſhall finally ſubjoin this caution, that almoſt all theſe hives will prove barren, unleſs males likewiſe are admitted into them at the ſame time with the females. The breeder of Bees who told me this, did not know how, according to their received opinions of the Bees ſitting on their eggs, to ſolve this difficulty; he allowed only this, that it might eaſily happen, that ſome of the Bees that are the ſitters, for by this names the males are called, might fly over, from the firſt, or the other neighbouring hives, to thoſe before mentioned; for unleſs the females were impregnated by theſe, no generation, as I myſelf think alſo, could follow.

It appears evidently from this experiment, how induſtrious the common working Bees are, and that they continue to perform their office, though the female be taken out of the hive; but if you carry off the brood from the hive immediately, they will give over their labours: ſo long as they have the eggs or young ones, you will never ſee the leaſt appearance of confuſion in the hive. Hence I demonſtrate clearly what is the office of the working Bees; they, together with the female, have no other office: but to nouriſh the young, and build little cells for them; whatever time they can ſpare from this work, they employ in collecting honey and Bee-bread. Theſe common Bees are in truth kept in ſlavery, and appear to have been created by God to labour inceſſantly.

In countries that are warmer and more fertile than ours, the Bees ſwarm more frequently, without the artifice mentioned before. This is confirmed by the following incident, which a creditable breeder of Bees now living related to me as an abſolute fact, which had happened to himſelf. He told me, that when the count de Manſveldt about ſixty years before had over-run the province of Embden, he had left him after that irruption one hive of Bees, from which the following year thirty ſwarms iſſued forth: that hive proved indeed extraordinary fruitful, after the reſt of his hives, as well as thoſe of his neighbours, were deſtroyed, for on that occaſion a vaſt multitude of Bees had betaken themſelves to it. The firſt ſwarm from this hive he ſaw on Aſcenſion day, and on the ſame day, a little while afterwards, another ſwarm alſo iſſued forth; the firſt of theſe two, after a month, ſwarmed again twice, and the other ſwarm that quitted the hive on the ſame day, after ſix weeks were paſt, ſwarmed three times. That ſame year there iſſued alſo, as well from the firſt hive, the parent of all, as it were, and from the other hives he had obtained from it, three and twenty more ſwarms, which with the former ſeven make thirty. It appears manifeſtly from hence, that theſe inſects are very prone to venery and extremely fruitful.

It is ſurpriſing as well as pleaſing to ſee in what numbers, and with what aſſiduity, the Bees beſet the mouth of the hive all around and without, when they are going to ſwarm: the elder female, who is at this time impregnated for the year by the new-born males, often begins the ſwarming. In the ſecond ſwarm, or when the Bees happen to ſwarm for the third time, ſometimes you may obſerve two or three females at once, each of which we diſtribute into peculiar hives, if there be a ſufficient number of Bees for them, but we kill ſome of them; if theſe are too few, the males for the moſt part remain in the old hive, ſince theſe, as I am fully perſuaded, have the moſt convenient opportunity of impregnating the females. Sometimes, however, you will find males even in the late-formed hive of the new ſwarm. This perhaps is the caſe when the female has not yet been impregnated, but that work is ſtill to be done.

Bees may be hindered from ſwarming, if all the males and females are taken out from the hive, and though there ſhould by chance ſome young female remain in the upper part of the hive, yet the whole ſwarming will be ſtopt, for this younger female continues barren. Whoever is deſirous to extirpate from the hive in the manner mentioned the Worms and Nymphs of the males, muſt go about it ſo as by no means to cut away all the combs but thoſe only which lie in the upper part, for thus the Nymphs and Worms of the males are lodged, and the Bees will be able then to carry out with activity the dead brood of males, and to cleanſe their combs again in a little time. Hence, indeed, this advantage ariſes to the Bees, that they have nothing to do afterwards but ſolely to gather honey, becauſe there are already in the hive a ſufficient number of cells prepared, which only want cleaning, and require but a little labour to repair them.

The ſwarming being finiſhed, when the Bees which have flown out have ſettled and fixed themſelves upon the bough of a tree or ſome ſubſtance, it is aſtoniſhing to ſee in how ſingular a manner, by the help of their legs, they ſtick to one another, and form as it were a perfect bunch of grapes, hanging on one another by the aſſiſtance of their claws. At that very time they can fly off from the bunch, and perch on it again; nay, even make their way out from the very middle of the cluſter, and ruſh into the open air, though they ſeem to ſtick to one another ſo extremely cloſe.

Bees that have weathered out the winter, begin in the month of March following to lay their eggs in great abundance; from that time they continue this work inceſſantly: firſt, the female lays her eggs in the cells of the common Bees; next, in four or five or more particular cells, from whence the young females are to come; and laſtly, ſhe depoſits the reſt in the hotteſt part of the ſummer, or near the time of ſwarming, into the cells of the males. If it ſhould happen that there are not in the hive any of theſe cells made for the males, for ſometimes they are cut away with the honey at the end of the year, then the common Bees, endued as it were with an unaccountable preſcience, build ſome expreſsly for that purpoſe; nay, theſe ſame Bees nouriſh the male brood in theſe cells with a care and affection no leſs than the hatred and fierceneſs with which they kill the ſaid very males, when, after the ſwarming time is over, the female is impregnated by them. Nor, indeed, is it difficult for the Bees to kill theſe males, for they are not furniſhed with any weapon to defend themſelves, and beſides they have waſted their ſtrength in the act of generation, wherefore it is eaſy to overpower them: indeed, they die otherwiſe naturally, for they are not fit either for collecting wax or honey for rearing up the brood, if they are not deſtroyed before that time by the other Bees who have been their nurſes, and atone by a violent death for the pleaſures they have enjoyed. Something ſimilar to this is perhaps alſo the caſe among the Ants; for the males which are winged are found among the reſt only at a certain time of the year.

To return from my digreſſion; it is proper to take notice that the working Bees, when they have firſt crept out of, or rather burſt from their cells, are of a much paler colour and more inclining to dun than the old ones; theſe being browner and ornamented with a yellowneſs not ſo deep as gold. Their ſting at that time has not come to its full ſtrength: the bag that contains the poiſon is as yet empty, from whence, if they are even then handled, they not only do not ſting, but do not ſo much as attempt it. After a very few days theſe young Bees acquire as ſtrong a colour as the elder; nor do they ever, as ſome idly fable, learn from the old ones the art of making wax and collecting honey: this is implanted in them by nature, and to perform it rightly they need no more than follow their own inſtinct. The reaſon why the Bees are paler at firſt than afterwards is this, that thoſe parts which are of a ſubſtance between horn and bone, in the head, breaſt, and body, being but lately ſtript of their ſkin, have not yet in the new-born ſtate their full hardneſs: their down is at that time more of a Mouſe colour, but afterwards their parts gain both hardneſs and colour, when more of their fluids have evaporated thence, and the pores of the parts mentioned are contracted cloſer.

Enough has been ſaid of the outward form, and of the generation, diſpoſition and actions of the Bees: I proceed next to the internal parts contained in the head, breaſt and belly, which I ſhall explain in the ſame order that I obſerved in treating of the Worm and Nymph. Thoſe parts that are incloſed in the head and breaſt, I ſhall expreſsly treat of when I come to deſcribe the male Bee. This only need be particularly obſerved here, with regard to the head in common Bees, that their teeth or jaws are larger than in the others, and are furniſhed with two ſtrong muſcles, the one larger, the other ſmaller, which are indeed of a very firm conſtruction, and take up great part of the ſkull, which is of a ſubſtance between horn and bone. The tendons of theſe muſcles are cartilaginous, approaching to a ſubſtance between horn and bone, and being encloſed within the fleſh, they there adhere on each ſide in the manner that we ſee the plumage on both ſtick cloſe to the quills in the feathers of Birds; but we may more properly compare this fabrick with thoſe muſcles in Crabs and Lobſters, which move their claws; for in thoſe the fleſh in the ſame manner is obſerved to be joined with the great hard tendons of thoſe muſcles; wherefore theſe ſmall muſcles of the Bees agree with the muſcles of other animals in their ſtructure, and are exactly ſuch as the diſtinguiſhed Steno has deſcribed them.

Since I have mentioned here the mutual ſimilitude which there is between the muſcles of Bees and thoſe of cruſtaceous animals, I would have this further obſerved, that, as in thoſe animals the bony parts are placed on the outſide of the body and within, ſo this obtains alſo after the ſame manner in the Bee; and this ſtructure is directly contrary to that which we obſerve in larger animals and men, whoſe fleſh is placed outermoſt, but the bones within, in the fleſh, or between the fleſh. However, the ſtructure juſt mentioned in the Bee, as alſo in Lobſters, does not conſtantly obtain throughout, for in thoſe places where the hard or horny bone, by which the joints of theſe animals are ſupported, is to bend, or where the articulations are placed, theſe tendons, together with a part of the muſcles lie bare; ſince, were it otherwiſe, there would ariſe from thence a great obſtruction in moving. But again, all powerful nature does not uſe this method in all the articulations, as may be ſeen about the joinings of the horns; for in theſe, all that is muſcular is encloſed entirely within the cavity of the bony or horny matter; conſequently the motion in theſe parts is obſerved a little leſs diſtinctly.

There remains another thing to be conſidered even in the common Bee, I mean the trunk or proboſcis, it being, like the teeth, much more remarkable in theſe than in the males. In this proboſcis we are to obſerve principally ſeven little parts; one of them, which is placed in the middle, Tab. XVII. fig. v. *i*, has no fellow, and is pervious like a hollow tube: this properly conſtitutes the tongue or the trunk itſelf: the other ſix little parts, diſpoſed in three pairs, ſurround the former on each ſide, being deſtined for aſſiſting the trunk in the act of ſuction, that it may be able with ſo much the more eaſe to draw out of flowers, and pour in by ſuction, the natural honey found in flowers. In the trunk itſelf its diviſions are to be conſidered, which are extremely elegant and regular, and are beſet all around with briſtly, and as it were triangular hairs, diſtributed in an elegant order. Some of theſe diviſions at firſt ſight I took for articulations; there are above a hundred of them, and ſome of them do not go through the whole thickneſs of the trunk. The ſtructure of the trunk alſo, together with its muſcles, and the manner in which the ſuction is performed, are very worthy to be obſerved: but before I proceed to explain theſe, I ſhall firſt deſcribe thoſe three pair of little parts which are placed above and near the trunk.

The two firſt little parts of the proboſcis *a a*, are partly of a ſubſtance between horn and bone, and partly membranaceous: they are ſet round with hairs, and are furniſhed with air-pipes diſtributed through the whole texture of them, though it be of a ſubſtance between horn and bone. Theſe tubes appear through it *bb*; the tips of them *c c* are a little bent, but where theſe parts are united with the root of the trunk *d d*, there they have a kind of an appearance of an articulation, by the help of which they may be bent,; near the trunk and the reſt of its parts, quite within, and as it were under the chin of the Bee, if I may ſo ſpeak, I repreſent them in this draught drawn a little outwards and ſideways, but the natural ſituation of them is juſt as Tab. XXV. fig. IX. under the letters *f f* in the Nymph ſhews. The uſe of theſe ſeveral parts is to contribute their aſſiſtance towards the moving of the trunk downwards, and underneath againſt the head, and a little towards the breaſt, as well as to aſſiſt in cloſing and confining it, together with the other four, or rather the two pair of little parts; and alſo towards defending, covering, and guarding it from injuries. I ſhould think that they alſo aſſiſted towards ſwallowing the native honey, drawn up by ſuction when the trunk is filled with it, or thruſting it further inwards towards the ſtomach, ſince they have power to ſqueeze the ſnout below and inwards ſtrongly enough.

The two other little parts of the trunk, Tab. XVII. fig. v. *e e*, which figure IX. of Tab. XXV. repreſenting the Nymph, ſhews in their natural ſituation under the letters *g g*, are placed a little higher than the firſt pair, but they are nearly of the ſame ſtructure. There is, however, this remarkable difference, that each of them has in the upper part, at their extremities, three joints, one, Tab. XVII. fig. v. *f f*, lower and longer, and the two others *g g* higher and ſomething ſhorter, which are all ſurrounded with fine hairs. Theſe little articulated parts do not, like the former, embrace or cover the trunk, but are only placed near it on each ſide, and, where they riſe up about the root of the trunk, they are alſo articulated. As to the uſe of this pair, I am entirely of this opinion, and without any heſitation conclude that they are of very great aſſiſtance to the trunk in the act of ſucking; ſince they as it were in the manner of two fingers aſſiſt the trunk, open the leaves of the flowers, and remove whatever elſe might chance to obſtruct it: therefore I compare theſe two little parts to the two fore feet of a Mole, by the help of which it puſhes the earth from the ſides both ways, that it may be able with its ſharp trunk to ſearch for its food the more conveniently. The two laſt little parts *h h* are much leſs than the firſt and ſecond, and are of a texture a little partaking of horn and bone, but rather membranaceous, and they are rough likewiſe with hairs: theſe, together with the trunk itſelf, are drawn inwards, and, as I myſelf think, the little articulated parts are aſſiſted by them in their operations, ſince they remove themſelves a little from the ſides of the trunk, and may very happily aſſiſt to puſh aſide the leaves of the flowers. Even by their motion they ſeem as if they were contrived to help alſo towards carrying the honey upwards, and preſſing it towards the ſtomach.

The ſtructure of the trunk *i* is partly membranaceous, and partly of a ſubſtance between horn and bone, or griſtly; but its hairy ſkin, full of cuts, muſt be conſidered particularly. Here, before I proceed any further, it is neceſſary I ſhould mention firſt, that I ſhall deſcribe and repreſent the trunk here in the under part, as it ſhews itſelf in the Bee when laid flat on its back. As to what regards that part of the trunk *k k* which is of a ſubſtance between horn and bone, it is formed in ſuch a manner, that it can fly off from the reſt of the trunk arch-ways, and ſpread itſelf in the ſhape of a circle, Tab. XVII. fig. VI. *b*; from whence it is that the membranaceous part *c c c c*, which lie moſt beautifully folded up under the griſtly part, fig. V. *k k*, and joined with it, may be conſiderably expanded on each ſide like a ſail, in the middle of which a maſt is fixed. This mechaniſm, however, does not ſhew itſelf plainly, unleſs we circumſpectly and nicely, with a very fine-pointed needle, raiſe that horny bone a little up: in that caſe it is at length ſeen how the membranaceous part of the trunk is folded, and how it expands itſelf; ſo that the internal cavity of the trunk *i* is prodigiouſly enlarged and widened, inſomuch that a very great quantity of native and undigeſted honey, in proportion to the ſize of the inſect, may be received into the trunk. Indeed, nearly the ſame courſe of nature is ſeen here, that we obſerve in Monkies, which can hide nuts and what other fruits they have gathered, in two membranous bags, which are placed on each ſide of their jaws: ſomething like this obtains alſo in ſome kinds of Birds, which in the membranaceous and expanded part of their bill, where the beginning of the ſtomach is inſerted, preſerve a Fiſh they have catched. Amongſt other water-fowls this is moſt obviouſly ſeen in that ſort of Cormorants, which in our way of ſpeaking we call Schoffers. Theſe birds once every year frequent the foreſt of Sevenhuſen, not far diſtant from Leyden, and are ſhook down from the trees in great numbers, and as ſoon as they fall into the water they are able to ſwim immediately, and to dive quickly under water, though they have never before either flown or ſwam. In the ſame manner Bees alſo have implanted in them the art of making wax, and gathering honey in their proboſcis or trunk.

Before I proceed further in the deſcription of the trunk, I ſhall inſert an account of the manner of their catching fiſh in ſome parts of Europe, by means of the juſt mentioned ſort of Cormorants: ſome few years ago many of theſe birds were carried to England and ſold for that purpoſe. In the firſt place then they make them tame, ſo that they may be brought to perch and ſtay upon the hand of their own accord: when after this they are inclined to go out a fiſhing with them, they tie to one of their legs a thin but ſtrong cord, which they keep rolled up in a ball: afterwards they hold this ball, which is wound round a little ſteel pin, by a wooden handle, as our girls do their bobbins, while they roll off of them the threads made on the reel: theſe things being prepared, they put a ring round the Cormorant's neck, and being now come to the fiſh-pond, they let the Cormorant fly down into the water; then the cord is rolled off of the ball with a whizzing twirl, and the Cormorant, to the great amazement of the ſpectators, quickly ſeizes ſome fiſhes: theſe, however, are ſtopt at the ring that has been put about its neck: therefore when the Cormorant is afterwards drawn out by the cord, he may eaſily be made to throw out again the fiſhes it had taken into the mouth, only by ſqueezing its ſtomach and throat upwards. A perſon of great credit and ingenuity told me this ſtory, who has himſelf ſometimes ſeen this manner of fiſhing. When I was in company with Mr. John Oort, an old friend of mine at Honſlaardik, I obſerved with aſtoniſhment that certain water-fowls there, when any fiſhes were given them, would always turn them expeditiouſly, ſo that they could take them in head foremoſt: this was done through great caution in them, that they might not be hurt by the fins of the Fiſhes, as they went down their throat. Whatever we could do to make theſe fowls ſwallow a fiſh tail foremoſt, they could not be brought to it; for they always uſed, by the help of their beaks, dexterouſly to turn the fiſh over. To return to the trunk of the Bee; it is to be obſerved, that the membranaceous part of the trunk has no hair on it, but in its place is covered all over with little protuberant pimples; theſe are tranſparent, and are placed there in regular order, and at equal diſtances from each other, and in ſome degree reſemble the little riſings obſervable on the ſkin of birds when their feathers have been plucked off: theſe little parts ſeem to be in reality glandules, which have perhaps a power conſiderably to change the honey that is ſwallowed down, and in ſome meaſure to forward the connection of it. This alſo is to be obſerved in regard to the ſtructure of the griſtly parts of the trunk, or that which is of a ſubſtance between horn and bone, that in the middle it ſeems to approach nearer to the nature of an horny bone, than it does at the ſides, which are of a little deeper or duſky red colour. This part of a ſubſtance between horn and bone, Tab. XVII. fig. v. *k k*, does not every where retire outwards from the trunk; for a little below the orifice or mouth of the trunk, it tends inwards *n n*, and, uniting with the other hairy part of the trunk in a narrower and thinner canal as it were, is then carried altogether inwards and forwards *o o*. But in the ſame place the whole trunk in its circumference is then crowded with ſmall hairs, like little claws a very little bent, which, whether they are open canals, or ſerve by way of little claws or hooks, to keep the trunk during the time of ſucking in its ſituation and place, I will not determine; for as yet I have not ſo clearly diſcovered how it is, though I make no doubt but it may be found by time and application. That portion of the trunk which is of a ſubſtance between horn and bone, at the end of that part where it verges outwards, has a globule or little head, which appears very remarkable; and in the middle of this an opening is ſeen, which ſeems to me to penetrate quite into the cavity of the membranaceous portion of the trunk; nevertheleſs I now find this opening is not, as I have before ſaid, ſo ſmall as the apertures of the lacteals, though under a microſcope it may appear ſo: indeed the beginning of it in this place, in proportion to the part, is ſo minute and narrow, that ſcarce any thing certain can be advanced about it to clear up all doubts. In Butterflies I am confident that the trunk opens with many lips, which imbibing the nouriſhment, appear at the end of the trunk like ſo many little hairs: but in the Bee a different ſtructure is obſerved; that little part or diminutive head of the trunk, Tab. XVII. fig. v. *o o*, together with its little membrane, in which the hairs are fixed, is able to contract itſelf into a narrower compaſs, and likewiſe to move itſelf inwards, as is manifeſt if this part be touched and examined at different times, and eſpecially if it be carefully examined in the younger Bees, and then in the more perfect. I have repreſented this in the form wherein I can ſhew it at any time. Further, this portion of a ſubſtance between horn and bone, at the lower part ſpreads into two legs as it were *p*, which are connected with the other lower portion of the trunk: where this connexion is made, there are diſcovered three more little parts of a ſubſtance between horn and bone *q q q*, perfectly black like pitch, ſhining, and joined to one another by ſeveral articulations. The middlemoſt of theſe is the ſheath as it were of the trunk, within which it at that time, when it is not employed in ſucking, by the help of ſome muſcles, is drawn back and concealed; at the ſame time alſo the other little parts likewiſe of the trunk bend themſelves, and retire inwards. In this ſheath of the trunk thoſe muſcles alſo are encloſed, which belong to the two pair of the articulated little parts of the trunk *e e*. The muſcles next of the firſt pair of theſe little parts, Tab. XVII. fig. v. *a a*, are placed a little lower, and are implanted with two horny little parts *q q* towards the outſide, of a blackiſh colour: but the two little parts themſelves, together with the ſheath of the trunk, are joined by four diſtinct articulations *r r r r*, to the extremities of the bony or horny parts, which together conſtitute the head of the Bee: ſo that the whole ſheath, the trunk, and its little parts, are, by the help of two ſtrong muſcles *ſ ſ* moved inwards at once; on which occaſion the parts juſt deſcribed bend themſelves backwards and inwards, and at the ſame time hide, cover, and ſhut in the ſheath. Theſe beforementioned muſcles *ſ ſ* here appear through a little thin membrane *t*, and under this the throat *l* alſo is ſeen, which, together with theſe muſcles, and the membrane covering them, is cut through in this figure.

We come now to the act of ſuction, which the Bee performs in the following manner; it gradually draws the griſtly part of its trunk, or that which is of a ſubſtance between horn and bone *k k* from the hairy ſkin and its diviſions, which done, the membranaceous and wrinkled part of the trunk *m* is ſtretched out and made ſmooth, but the griſtly part is diſtended arch-ways: when this is performed by the help of the muſcles of the trunk, the ambient air is neceſſarily forced out of its place, and by the preſſion of it the honey is carried inwards, and through the cavity of the trunk.

In Butterflies, on the contrary, this is performed in quite a different manner; for as much as in theſe the trunk is not ſingle, as in the Bee, but double; which alſo, after the ſuction is ended, is wonderfully curled and rolled up together, by numberleſs moſt minute articulations; ſo that Butterflies muſt execute their ſuction in a quite different method, namely, by pinching cloſe the points of reſpiration, and ſwelling out their body, they repel the air, and this being driven out, puſhes forward into their trunk the ſweet moiſture for which they gape in ſucking. The doing this is very eaſy to the Butterfly, ſo that I ſhould think even the Bee too, while it is ſucking, does the ſame thing, for what hinders, but that this or ſomething ſimilar may be performed by the Bees, ſince their points of reſpiration, though membranaceous within, have a horny edge, by the force of which they can open themſelves into an oblong ſlit, and cloſe themſelves again, in like manner as the Frog ſtretches out and ſhuts again the upper part of its wind-pipe, as the moſt renowned Malpighius has obſerved with the utmoſt exactneſs? I might now deſcribe all the muſcles of this part, one by one, and repreſent them in figures; but that would involve me in a work requiring both a vaſt length of time and endleſs labour: this is the reaſon alſo that has hindered me from purſuing many other particulars, which I have here delivered to the utmoſt, and with the ſtricteſt accuracy.

Should any one now aſk me, whether the Bee can ſuck no other way, than by ſtretching out or moving arch-ways the little griſtly part of its trunk, I anſwer, that it entirely appears to me, that even by barely pinching cloſe their points of reſpiration, and ſwelling out their body, the Bees may be able to perform their ſuction; for nothing hinders, but that even by theſe means alone the air that is driven out may puſh the honey inwards. We obſerve alſo that the Bee, when going to ſuck in the air in its little pulmonary tubes, moves the rings of the belly within and without, in the ſame manner as we do our breaſts in the act of breathing; but becauſe the thorax in Bees is immoveable, therefore their belly performs this office. This little part, which has been now deſcribed, is worthy of the higheſt notice; nor can I here forbear owning, to the glory of the immenſe and incomprehenſible Architect, that I have but very imperfectly and ſuperficially attempted to deſcribe and repreſent this little part; for to repreſent it to the life, in its full perfection, as truly moſt perfect it is, far exceeds the utmoſt efforts of human knowledge: and in very truth, our intellects and abilities fail us every where, when we venture even no further than to contemplate the divine wiſdom in the works of God, which can never be worthily magnified. Think then how much more excellent they muſt have been before they became obnoxious to deſtruction! in reality, this ſingle little part is formed with ſuch exquiſite ſkill, that it may juſtly be ranked among the chief inſtances of the omnipotence of the Deity. But I would have this underſtood according to the narrow limits within which our capacities are confined, for we ſee the works of God only as through a glaſs darkly, ſince our underſtanding reſembles an ignis fatuus, a Will-with-a-wiſp, and is utterly unfit for diſcerning theſe things, which ſo ſurpaſs all mortal comprehenſion.

In other ſorts of winged inſects approaching to Bees, for example in the Waſp, the trunk is much ſlenderer, nor is it of ſo remarkable a length; the reaſon of which difference ſeems to me to be this, that in theſe inſects, beſides the trunk, there is another way ſtill by which they can draw in their food, ſince they are little creatures of a very rapacious, ſavage, and greedy nature. This is eſpecially manifeſt in that larger kind, which we call Hornets, which are rapacious to ſuch an amazing degree, that even when cut through the middle of their body, they do not refuſe to eat; and if then you give them honey, or ſugar moiſtened with water, which is much the moſt proper, they ſuck it in ſo greedily, that you may ſee it again running out at the wounded part. I have conſidered the trunk in the largeſt ſort of Waſps, a draught of which, for its great elegance and particularity, I ſhall give in this place.

A delineation of the trunk or ſnout of the Waſp, as ſeen from underneath.

TAB. XVII. FIG. VII.

a Is a part of the horny ſubſtance at the bottom of the head; it is ſhagged at the ſides with yellow hairs, is marked alſo with two yellow ſpots, but for the reſt it is black, and ſhining.

b b c Are three little horny parts, at the root of the trunk; theſe are of a ſhining black, and two of them that are at the ſide *b b* contain in them thoſe muſcles, which move the articulated briſtles *d d*; but the little horny part in the middle *c* is, as it were, the ſheath of the trunk itſelf *f*, in which, beſides the muſcles of that organ, thoſe of the other two articulated briſtles *d d* alſo are depoſited.

d d d d Are four articulated briſtles, that aſſiſt the trunk during its action.

e e Is the place where the teeth have been broken off.

f Marks out the trunk itſelf, in which are ſeen four delicate white little parts, furniſhed toward their tops with round and yellow globules. All the parts hitherto mentioned are covered over with hairs, which indeed I have not exhibited here with them, leſt it ſhould create confuſion. It is to be obſerved alſo, that all theſe parts are repreſented as in the Waſp laid along on its back, from whence it is, that we can ſee but half of ſome of them.

If a Bee is opened on the back, there firſt preſents itſelf a limpid or clear humour iſſuing from the veins and the heart, which are wounded; for the heart is placed oblong in the back, as it is in the Coſſus, Silk-worms, and many other inſects.

The muſcular fibres alſo are ſeen, which move the rings or inciſions of the body of the Bee, and are the ſame both in ſituation and ſtructure, as I have ſhewn them in the Coſſus.

The fat alſo appears, conſiſting of little round parts, which have been fixed to their membrane.

The lungs are more than all other parts remarkable; theſe are two white and tranſparent little veſſels, fig. IX. *a a*, conſiſting of the pulmonary tubes dilated, and running together. Theſe lungs are entirely membranous, and fall together when the air is out of them, which is by no means the caſe with the tubes that proceed from them, inaſmuch as they, conſiſting of rings curled around, remain always open. The lungs, compoſed as I have obſerved of dilated ramifications of the wind-pipe, terminate again in little tubes, Tab. XVII. fig. IX. *b b*, which are annular; and theſe, then here and there widening, grow into little bladders *c c*, and theſe alſo contract themſelves again into little tubes *d d*. This alternate mixture of bladders and tubes, however, is not ſo frequent in the Bee, as in the Rhinoceros Beetle, whoſe lungs conſiſt of numberleſs little bladders, which may in ſome meaſure be compared to the pods of the plant called Honeſty, while yet hanging from their ſtalks. In Bees the lungs are principally compoſed of two large bladders; there are likewiſe beſide them ſome ſmaller, and the remaining part is made up of little tubes, which then, as in the Worm of the Beetle, or as in the Worm of the Bee itſelf, are diſperſed over all parts of the body *e e*, &c. ſo that the lungs, by the intervention of the little tubes which they ſend out, communicate every where with themſelves by mutual inoſculations *f f*.

When a Bee is opened along the belly, immediately the ſpinal marrow comes in view, and this I am now going to deſcribe: nor ſhall I here ſtop to mention either thoſe parts which are ſeen in this view beſides, and have been mentioned before, or the extremities of the rings, which are membranaceous and terminated by black edges of a ſubſtance between horn and bone. The ſpinal marrow is the principal part, which now preſents itſelf to be conſidered; it conſiſts, as in the Silk-worm, of nerves and little knots, which owe their riſe to two nerves as it were proceeding from the brain, though there ſeems to me to be beſides theſe ſome ſubſtance of a different nature from them in the ſame place, which, for the ſake of ſtrengthening them, binds the little knot and the nerves together: this is ſeen alſo in Silk-worms; nay, and in the human ſpecies, theſe nerves, which are ſwallowed up as it were in little knots, are ſeparated from one another here at a more conſiderable diſtance, and open much wider aſunder, than in the marrow of Silk-worms; indeed, the marrow in Bees is almoſt every where open or ſplit into two parts, while in Silk-worms it opens only at diſtances. What are diſtinctly called the nerves by anatomiſts, are thoſe ſhoots which ariſe from the ſides of theſe little knots. If we trace the courſe of the marrow near the lower rings of the belly, there the nerves, ſpringing from the little knots, are ſeen, and they diſperſe themſelves among the muſcles deſigned for drawing the ſting inwards and thruſting it out. The other viſcera moſt conſpicuous in this view, are the ſtomach, the guts, and ſome parts belonging to the ſting.

The ſtomach, the gullet leading to which is moſt exceſſively narrow, ſeems to me membranaceous and thin, though it has ſome fleſhy fibres. It is often filled with honey, which is eaſily diſtinguiſhed by the taſte; the pylorus follows the ſtomach, and after this comes in view another little part, ſomewhat more protuberant, and inclining to a colour between yellow and red, which however, when more accurately inſpected, proves to be only ſomething ſhut up within the hollow of the inteſtine, and ſhining through in that place.

Next follows an inteſtine, which in ſome meaſure reſembles the colon in other animals: this gut is much thicker than the ſtomach itſelf, eſpecially when it is full; it has moreover ſtrong muſcular fibres, which, when they act, turn it up in many wrinkles and folds; its cavity is commonly full of a whitiſh matter, which ſeems to me to reſemble the white of an egg that has been ſteeped for ſome time in rectified ſpirit of wine, and is juſt beginning to curdle; or it is like ſtarch mixt with a ſmall quantity of water. If this little gut is pricked with the point of a lancet, the matter juſt mentioned flows out.

Further down this gut is conſiderably contracted and made ſmaller: but there, where this contraction begins, an infinite number of whitiſh filaments are ſeen, like thoſe which in the Coſſus I have called ſaffron-coloured veſſels. Theſe filaments or minute inteſtines are faſtened to the gut, in that part where it is contracted, as well as elſewhere. This cloſe connexion of them with the gut is extremely ſtrong, and is effected by means of the pulmonary tubes, which, as they run through the whole body, ſo in this place particularly they are an inſuperable obſtacle to the diſengaging theſe little guts. I believe it would take me up ſome months to ſearch this matter thoroughly to the bottom, which truly ſeems to be by no means deſpicable, nor unworthy that ſo much pains ſhould be employed upon it, as I ſhall hereafter ſhew.

The gut, after it has been contracted in the manner already mentioned, dilates again on a ſudden, though here it ſeems to be altogether membranous; but as it is at the ſame time tranſparent, ſome little, whitiſh, and oblong parts are ſeen on the outſide, as ſhining through it: theſe, when the gut is opened, are found to be ſix in number, and are glandular, and they are not every where uniformly whitiſh, but are filled with watery and tranſparent qualities. Theſe ſix little glandular parts ſwell out very conſiderably on the inner ſurface of the gut, within its hollow, and are there very conſpicuous. I have alſo perceived little parts of the ſame kind in the inteſtines of Hornets. It is obſervable beſides, that the extreme part of the inteſtine, in which theſe ſix little parts are found, is ſometimes ſwelled, almoſt beyond what could be believed, with excrements. Theſe are of a pale yellow colour, and are divided into ſmall pieces, like bee-bread, though their little lumps are neither round, nor of any other regular figure. One may further remark, that the inteſtine, in which theſe ſix oblong glandular little parts are placed, is ſometimes found as fully diſtended with an aqueous humour, of a yellowiſh colour, as with the yellow and more ſolid matter beforementioned. But this is only in very young Bees juſt produced from the Nymph.

This gut is again contracted where it ends, but from that part it again dilates itſelf, and at length forms the rectum or laſt gut. This extreme part of the inteſtine ſometimes wants the laſt contraction, and in that caſe appears rather like rumpled linen, or a cotton handkerchief, drawn through one's hand. The inteſtine finally terminates under the point of the ſting where the excrements are voided, and the rectum ariſes from it.

If theſe guts joined to the ſtomach are laid on a thin plate of glaſs, and heated by the flame of a lamp till thoroughly dried, then you may ſee not only their circular fibres, but even thoſe valves which have been called by Kerkring in the inteſtines of men, the valvulæ conniventes, and which were deſcribed and in ſome manner delineated by Spigelius. Ruyſch firſt, in the year 1667, demonſtrated them in an inflated human gut. I have made the ſame obſervation alſo in the Bee and Waſp.

Behold! theſe are the entrails of the common or working Bee; there does not appear among them the ſmalleſt trace of ſpermatic organs or the genital parts, or of any thing which can anſwer the purpoſe of, or even be compared to a penis or ovary. Hence I think theſe Bees may moſt juſtly and properly be ſaid to be natural eunuchs, and ſuch as can only work and feed, cheriſh and rear the progeny of others as their own. On the contrary, as I have beforementioned, the genital organs are very plainly ſeen in drones, as they are the true males of the Bees: their whole belly is in a manner filled by the teſticles, as I ſhewed to his ſerene highneſs the grand duke of Tuſcany, among other wonders of nature, in the year 1668, when he graciouſly condeſcended to approve of my labours.

I ſhall now proceed to the ſting, that wonderful work of nature, and eminent example of the wiſdom of the great Creator. It is placed in the hinder part of the body, its point lies juſt over the end of the rectum or ſtraight gut: the ſting is therefore placed in the laſt rings of the belly, with which it is alſo very remarkably jointed, by means of ſome cartilages. But as the ſting is worthy of the greateſt attention, I ſhall deſcribe it at large, together with all the parts ſubſervient to it, having in view only the praiſe and glory of the moſt wiſe and excellent Creator. In the ſting there are diſcovered, firſt, the channels through which its poiſon is conveyed to it: Secondly, its cartilages. Thirdly, its muſcles. Fourthly, its two pieces called legs. And laſtly, the ſheath within which the legs which properly conſtitute the ſting are hid.

That the ſting has poiſon in it, R. Hooke, a writer of great experience and learning, has in ſome meaſure laboured to demonſtrate in his ineſtimable micrographia, written in Engliſh, thinking that the poiſon lay hid in the hollow thickneſs of the ſheath of the ſting, which however is never the caſe, unleſs by mere accident.

Let any one with a forceps or little ſteel tweezers take hold of the legs, wings, or which laſt will be moſt convenient, the breaſt of the common Bee, and he will generally ſee a ſmall clear drop as it were of water hanging on the point of the ſting. In this water the poiſonous quality of the Honey-Bee is properly contained. This, as ſoon as it drops into the wound, produces the pain that follows the wound; for the ſting itſelf is not in the leaſt degree venomous, nor does its puncture hurt more than that of a needle. For experiment's ſake I have often wounded myſelf with the ſting, and felt no other ill conſequence from it than a ſlight itching in the wounded part; but the ſting muſt be firſt thoroughly cleanſed and well ſqueezed and wiped for this trial, for it might otherwiſe probably happen that the injury would be more conſiderable.

To proceed in order, I would have it obſerved, that the venomous liquor which only paſſes through the ſting is originally depoſited in the belly of the Bee, and there contained in a little bladder nearly tranſparent. This little bladder is of an oblong figure, and of a very ſtrong texture, ſo as to bear the force of the fingers preſſing it without any damage: nay, ſo great is its firmneſs, that the belly of the common Bee being opened, let this little bladder be taken hold of, and the whole ſting and all its parts may be eaſily drawn with it out of the body, without the bladder being broke. I have found this bladder of poiſon ſo ſtrong, even in the ſmaller kinds of Waſps, that by preſſing it with my fingers as hard as I could, the poiſon might be thrown to the diſtance of two foot from it through the ſting. It is further remarkable, that a very ſtrong muſcle twines about this little bladder, and has its tendril in the middle, as it is in the muſcle called the temporal muſcle in the human ſpecies. When that muſcle contracts itſelf, the poiſon is by its force ſqueezed out and thrown into the wound, ſo that the ſting may be compared to a ſmall ſyringe; the little bladder or rather the muſcle of it juſt mentioned ſerving it in the ſtead of an impelling plug. But I have not hitherto diſtinctly examined this muſcle in the common Bee: I have ſeen it in the Waſp, and moſt conſpicuouſly in the Hornet, after I had firſt kept that inſect a whole year in balſam. This method I ſome years ſince diſcovered, and by it the parts may be moſt happily and diſtinctly viewed. There comes out of this little bladder, in every ſpecies of Bees, a ſmall thin tube, which is extended as far as the ſheath of the ſting, and this at length runs between the two open legs of the ſting, enters into the ſheath, and terminates in the thickeſt part of it. It is by this channel that the poiſon is conveyed from the little bladder through the ſheath into the ſting, and paſſing from the hollow part of the ſheath between and under the legs of the ſting, it is darted into the wound when the Bee gives the ſtroke.

On one ſide of the little poiſon-bladder in the Bee, is ſeen a ſmall, oblong, thin, crooked tube. Of this kind I have obſerved two in the Hornet, in which creature the poiſon-bladder is alſo twice as large as in Bees. I have ſeen beſides other ſmall tubes growing laterally out of that I mentioned, but I could not immediately diſcover whether they terminated. I afterwards however obſerved in Waſps and Hornets, that in the body of theſe animals there are two diſtinct little tubes, Tab. XVIII. fig. IV. *c c*, inſerted into the hinder part of the poiſon-bladder *a*, through which little pipes the poiſon is conveyed into that bladder, and in which the poiſon is properly ſecreted. Theſe ſmall pipes appeared unequal, with little ſwellings here and there, as is ſeen *d d d*, and terminated in cloſed endings *e e*, as the blind guts of Hens, which ſame thing I have obſerved alſo in Bees. Theſe ſmall veſſels are much wider towards the hinder parts than in the fore parts, and about their extremities where they are cloſed, they are very thickly ſurrounded with fat and pulmonary tubes, for which reaſon they cannot be ſeparated from the other parts without great difficulty. I have alſo remarked, that theſe poiſonous veſſels in Bees very nearly reſemble thoſe which are found in Waſps, and are juſt ſuch as I have in the third figure, Tab. XIX. *z*, drawn to the life in a female Bee: *z* denotes the poiſon-bladder in the female; *γ* the ſluice of the bladder; *α* the ſmall tube in which the poiſon or venom is ſecreted, *β β* are the cloſed ends, the ſmall tube in which the poiſon is concocted. Theſe appear to conſiſt of a two-fold ſubſtance; the one glandulous, of a whitiſh colour, and not of a very firm texture; the other is membranaceous, with ſomething like a filament quite tranſparent, which ſticks within the former ſubſtance, by which it is ſhut in and ſurrounded, like the ſmall tube of the veſſel called the vas deferens, which is in itſelf extremely ſlender, and is alſo compaſſed about by a glandulous and nervous ſubſtance. The former ſubſtance is very eaſily ſeparated in the handling of it from that within, which is ſkinny, tranſparent, hollow, and very much like a fine hair. This ſmall tube is beſides very ſtrongly joined to the ſaffron-coloured veſſels by numerous pulmonary tubes, ſo that at firſt ſight I ſhould have thought theſe veſſels were productions of the ſmall tube; but as they are moſt ſtrongly fixed to that part where the gut contracts itſelf, and the ſubſtance they conſiſt of curdled in my balſam; whereas, on the contrary, the humour contained in the ſmall pipe of the poiſon-bladder remained clear and bright in the ſame balſam, I was thoroughly convinced from thence, and from what I have before mentioned, that this ſmall tube has no communication with the ſaffron-coloured veſſels.

When the poiſon-bladder is put into my balſam, it is ſometimes tinged with a purple-colour or redneſs. I likewiſe have ſeen it green, in the Hornet. And we muſt further obſerve, that the poiſon-bladder in Bees, as I have often obſerved, is not contracted in a globular form, like the urinary bladder in the human ſpecies: ſo far from it, that its ſides are like two planes preſſed together. This may be ſeen if you cut off the Bee's wings, and then greatly irritate or provoke the creature; for then it will, in revenge, throw its poiſon out of the ſting, being every moment eager to ſtrike and wound.

Let us proceed. The ſting then, as I have ſhewn, is ſituated under the rings of the poſternal parts of the body, and is there moved in and out by the help of certain muſcles; and as theſe muſcles are affixed to ſome horny or bony little parts, I ſhall therefore briefly deſcribe theſe parts. There are chiefly ſix principal little parts, together with two others leſs conſpicuous. The legs or ſhanks of the ſting are articulated with theſe horny or bony little parts, which are likewiſe joined with each other, ſo that by means of this ſtructure they may be moved in and out, and up and down, and on either ſide. This motion is performed by the force of the muſcular parts, which I find to be eight in number, four very manifeſt, but the reſt leſs conſpicuous. The horny or bony parts, and even the ſhanks of the ſting, are inſerted in all theſe muſcles. Two of the muſcles, which are ſomewhat leſs conſpicuous, encompaſs or ſurround that ſide of the ſting which is the thickeſt, being connected with the caſe or ſheath. There is likewiſe a ſmall horny or bony part there, conſtructed or formed in the ſame manner as the little bone in Birds, called the perſpicillum, which is properly produced or originated from the collar-bones concreted together. This little part is particularly articulated, and by the help of its muſcles ſeems to move the ſheath or caſe of the ſting regularly outward.

I ſhall now deſcribe the ſhanks of the ſting, and ſhew that it is not a ſimple but compound part; that it conſiſts of two ſhanks, and a ſheath wherein the ſhanks are kept, like two ſwords in one ſcabbard. Theſe ſhanks of the ſting are not conſtructed in the manner of the crura of the penis or clitoris, which ariſe each from a diſtinct place, and at length meet and conſtitute one body; for the ſhanks of the ſting continue all the way diſtinct from each other, though their points be ſo near to each other, that the intermediate ſpace can ſcarce be obſerved, and no body thinks he ſees any thing but one point. Each of theſe ſhanks is furrowed on one ſide, but on the other it is ſtrengthened by certain hooks: hence, whilſt the equal ſides and points of both ſhanks are joined together, the ſting is provided from each ſide armed with hooks. But, in order to underſtand this matter juſtly, one muſt know the ſtructure of the ſheath of the ſting; and therefore I would have it obſerved, that this caſe or ſheath is not in reality diſpoſed in ſuch a manner as the ſcabbard of a ſword or knife, or like the caſe of a rocket: by no means, for the ſword, knife, or other weapon are on each ſide hidden in their ſcabbards, and ſurrounded or covered entirely by them, nor is the caſe of the ſting made like the ſmall open tube or canula, through which ſurgeons paſs their inſtruments, when they are to cut a particular part in ſuch a manner as that the adjacent parts may remain unhurt. The caſe of the aculeus is more like the horn-book made in our country for children, or one of thoſe caſes, the verge of which is furrowed and receives a moveable cover. The ſheath is formed nearly in this manner: its inner ſide each way is prominent, or has a riſing back, or it is ſomewhat bent with a double margin; but theſe backs, like bolts, agree with and are joined to the furrows of the ſhanks of the ſting, and therefore theſe ſhanks are very eaſily and conveniently moveable up and down, like the operculum or cover in the furrow of the caſes juſt named. But the ſting itſelf is ſituated in ſuch a manner in this ſheath, that its points lie as it were in the open cavity, but the crooked hooks ſhew themſelves out of the ſheath's cavity; except when the ſting appears beyond the extreme verge of the ſheath, and is conſequently thruſt out: therefore, the lower ſide of the ſhanks of the aculeus or ſting lies always in the cavity of the ſheath, and the upper ſide is out of it. Theſe ſides of the ſhanks have crooked hooks, hang out of the caſe, and receiving in their furrows the internal ribs and prominences of the ſheath, they are moved eaſily along the latter; whilſt, in the mean time, their upper ſides being ſmooth, are applied to each other, and with their united extremities they form the point of the ſting.

Further, it is proper to obſerve that one of the ſides of the caſe or ſheath is not open through its whole length, nor does it reſemble the inſtrument before named, equally extended without its valve: it is rather on the hinder part, where it is broadeſt, and united together, under which part the ſhanks afterwards paſs. This is very particularly and plainly obſerved in the ſting of the Hornet, in which the ſheath entirely coaleſces in the hinder part where it is thickeſt. But in Bees theſe minute and narrow paſſages are no where entirely united; therefore the ſheath in that place embraces the ſhanks of the ſting, at leaſt in part, by that means preventing thoſe ſhanks from moving out of their places, as may be ſeen, Tab. XVIII. fig. III. unders the letters *d d*.

Each ſhank of the ſting has uſually ten crooked hooks near its point, and ſome others which are leſs remarkable: but the ſheath or caſe has no hook at all; becauſe if it had, the ſting itſelf could not move backward and forward in it. Since therefore each ſhank has ten hooks, the ſting, when the Bee has given its ſtroke, is kept in the wound, being fixed there by twenty bearded hooks; and the more the Bee endeavours to draw the ſting out, the deeper its hooks penetrate into the wounded part. But if the ſting be taken out of the body of the Bee, together with the inteſtines and other parts, as I have mentioned, it may notwithſtanding then inſinuate itſelf more and more deeply into the wound, being in this reſpect like the heads of vipers, which will bite after they are cut off. This we are clearly taught by experience, ſince we ſee that when the ſting is drawn out of the body of the Bee, it penetrates ſtill deeper into the wound, trembling, and as it were ſhaking in all its parts. The reaſon of this is evident, for the ſting is thrown out together with its ſheath, and all the cartilages and muſcles belonging to it, together with the poiſon bladder. I have often made the before-mentioned experiment in tan-leather gloves. The Bee muſt firſt be ſuffered to fix its ſting in them, and then it muſt be taken by the wings and pulled away forcibly, ſo that the ſting may be drawn out of the body. One may ſee that the ſting penetrates deeper and deeper into the leather: nor indeed is there any thing to hinder the doing of this, ſince the ſting conſiſts of the two ſhanks before deſcribed; which, as their tops or ends are united together, ſo both and each of them ſeparately may be moved: therefore, whilſt one ſhank is fixed in the wound, the other may be thruſt further and deeper; and where this latter lies firm by means of its crooked hooks, the former, on the contrary, may be inſinuated deeper into the wound, or thruſt into it deeper than the former. By this means the ſting and its ſheath penetrate further into the wound. Therefore it frequently happens, that the ſhank of the ſting is drawn further back into the caſe, and the other thruſt out of it in proportion. Thus when the Bee hath ſtruck the glove, and the ſting is then taken out of it, it is frequently found that one ſhank appears further ſtretched out of the caſe than the other; that is, the two ſhanks of the ſting have been then unequally fixed, and one is ſtruck in more deeply than the other, and fixed there by means of its crooked hooks. When the ſting with its appendages has been juſt pulled out of the Bee, if it be lightly put into any callous part of our ſkin, the ſame conſequence naturally ſhews itſelf: for it is then plainly obſerved, that the ſting penetrates every moment deeper and deeper into the wound; but however it does no harm, provided the callous part be thick enough to prevent the poiſon from reaching or entering the blood-veſſels, for that naturally diſcharges its ſtrength into the blood.

It is now time to treat more particularly of the beards or crooked hooks of the ſting. If you put them under a powerful microſcope, you will ſee them almoſt like Cats claws, that is, they are ſomewhat bent inwards, and their extremities are entirely tranſparent, but they are not moveable like the claws of beaſts: the ſhanks that conſtitute the ſting and their crooked hooks are all plainly cartilaginous and ſufficiently flexible, but they are connected by no articulations.

No joints are obſerved either in the ſheath or the ſting itſelf, though I was once of the contrary opinion. My error aroſe from hence, that upon handling it the air run into the cavity of the caſe, and by its clearneſs or brightneſs, and by the bubbles it formed, rendered conſpicuous the poiſoned liquor, which ſtill remained in the ſheath, ſo that it appeared to me as if the caſe itſelf of the ſting was articulated or jointed.

If the ſting be ſeen ſtretched or protruded out beyond the extremity of the ſheath, and at that time the Bee diſcharges its poiſon, then this poiſonous liquor is not thrown out beyond the caſe, but appears upon it like a little drop. But when the ſting is moiſt or wet, the poiſon alſo is further diffuſed, as it happens when the Bee gives any perſon a ſtroke, and afterwards inſinuates its poiſon into the wound. Nor can it be otherwiſe, ſince the ſting, the hinder part whereof is thicker, ſtops or cloſes up the wound ſo entirely, that the poiſon has no entrance or paſſage into it, but through the interſtice of the ſhanks of the ſting itſelf.

Therefore the proverb applied to Bees is very true, "There is no honey without ſome gall." Though I can find no bile in this inſect, yet the poiſon thus called gall may be diſtinguiſhed very clearly in it; nay, a great quantity thereof may be eaſily collected: this I ſhall at ſome time endeavour to do, when I ſhall make experiments on this poiſon. It would indeed be eaſier to obtain it out of the Hornets, Waſps, and Humble-Bees, the poiſon-bladder of which is larger; but one cannot get theſe creatures in ſuch numbers as Bees. If any one deſires to examine the Bee's poiſon-bladder filled with poiſon, he muſt kill the Bee, which may be done by throwing it into a bottle of ſpirit of wine. The Bees may be otherwiſe killed without handling them, by the ſmoak of that kind of fungus called crepitus lupi, or the puff-ball, or with that of linen cloth folded as in making tinder. The latter, in my opinion, is the beſt way of killing them: for though you handle Waſps, Humble-Bees and Hornets ever ſo little, they immediately diſcharge their virus or poiſon out of their formidable ſting, and then none of it is found in the bladder, which is otherwiſe full of it. I preſerve ſome ſuch bladders in my collection, as moſt extremely meriting the inſpection of the curious.

The poiſon is collected in the following manner: draw the ſting and poiſon-bladder together out of the body, and then the bladder, as I repreſent in Tab. XVIII. figure v. being taken with the tip of the fingers, put the point or top of the ſting into a thin glaſs tube, and then preſs or ſqueeze the poiſon into the latter through the ſting out of the bladder: you may afterwards blow the poiſon together into another glaſs veſſel, and make the experiment thereon; but all this muſt be done very ſpeedily, ſince this poiſon is eaſily coagulated when out of the body. Another method is to wound the bladder a little, and then to immerge or put into it the top of a thin glaſs tube; and thus the humour will deſcend ſpontaneouſly, or be forced into the tube: but the former method is better than the latter for thoſe who are expert in theſe things.

When the poiſon is expreſſed out of its bladder, it very eaſily exhales, by reaſon of its ſubtile and ſpirituous nature, leaving a conſiderable cruſt on the glaſs, which when ſcraped off appears like duſt: whether this duſt has ſtill any poiſon, is yet unknown to me. The poiſon which the Bee diſcharges through its ſting in the form of a round drop, ſometimes concretes about the ſting itſelf, preſerving the ſame round ſhape, and thus affords a very agreeable ſpectacle, for it reſembles a little drop of clear water, hanging as it were out of the ſting.

When the Bee hath given a wound, the ſting, as I have obſerved before, uſually remains in the wound by means of its hooks. But whether the Bee can wound or pierce the ſkin with its ſheath only, and ſo not leave its ſting in the wound, is ſtill unknown to me. The ſheath is indeed very ſharp. The Bee therefore ſeems able to wound with this alone, if it draws in the ſting at that time; ſince we likewiſe obſerve, that this ſting is not always equally prominent out of the caſe; it ſometimes lies entirely out of the extremity of the ſheath, and is ſometimes lower and ſometimes higher up in this its caſe.

When the ſting remains fixed in the wound the Bee muſt die; for, beſides the ſting itſelf, the Bee then loſes its inteſtinum rectum, or the ſtraight gut, and the parts annexed to it; nay, even the horny parts and their ligaments are broken off from the extreme rings of the body, to which they are united. And we are particularly to obſerve here, that the whole poiſon-bladder, together with the ſting, is then drawn out of the Bee's body; and as it remains out of it, it ſtill compreſſes itſelf by the laſt action of its muſcular fibres, and drives its poiſon deeper into the wound. For this reaſon, if any one be ſtung by a Bee, it is by no means proper to take the ſting by the hind part in order to extract it or get it out, becauſe, by this means more poiſon is always thrown into the wound. It would be better to cut off with a pair of ſciſſors all the parts of the ſting which hang out of the wound, and then to take out the reſt with a ſmall needle. I have ſometimes ſeen the ſtomach itſelf drawn with the ſting out of the body of the Bee.

If you would render the poiſon of the Bee ineffectual, and the Bee itſelf tame, make it thruſt its ſting into a piece of leather, and then cut off the top of it; by this means all the poiſon flows out of it, and the creature becomes tractable and gentle whilſt it lives, nor can it afterwards, though it ſhould probably generate poiſon anew, do any miſchief.

From what has been here ſaid, it appears how dangerous it is to irritate Hornets, ſince they have very formidable arms, and always carry poiſon about them.

In Hornets the poiſon-bladder is exceſſively firm, and is twice as big as in Bees. The learned Mouffet relates a very remarkable thing of theſe creatures: he ſays, the very accurate Penny ſaw a Hornet kill a Sparrow with a ſtroke of its ſting. Theſe are his words: "Whilſt Penny was at Peterborough in England, he ſaw in the ſtreet a Hornet in purſuit of a Sparrow, which it ſtruck at laſt with its ſting and immediately killed it, and, to the great aſtoniſhment of the ſpectators, fed itſelf with the blood of the dead Sparrow." How terrible theſe creatures are on account of this poiſon which they carry about them, is likewiſe evident from the promiſe formerly made by God to the Iſraelites in Exod. xxiii. "I will ſend, I ſay, my terror, like a Hornet before you, who ſhall drive out the Hivite, the Canaanite, and the Hittite from before thee." But God has no need of theſe hoſts to chaſtiſe his people; he can do it even by the ſmalleſt inſects, and convert the duſt of the earth into Lice, if the number of other plagues ſhould chance to fail: for what is above the power of him who ſhews himſelf adorable in all his works?

The queen or female Bee is furniſhed with a ſting, as I ſhall afterwards deſcribe in the diſſection of that kind. Among the Hornets the females only have ſtings, which are longer, ſharper, and ſtronger than in the Bee, and armed with ſeveral frightful hooks. How the males of the Humble Bees and Waſps are circumſtanced, in this reſpect, I have not been yet able to examine, on account of the variety of buſineſs wherein I am engaged. I would only have it obſerved here, that the males of the Hornet have no ſting, in like manner as the drone or male is without it among Bees; that the males of theſe two ſpecies agree in this reſpect, and are very peaceable creatures, free from all miſchief and injurious deſigns, and delight in love and generation only. There is the like meekneſs obſerved alſo in the males of Ants, and their teeth are therefore much ſmaller than thoſe of the females: among Ants alſo there is a third ſpecies which do not contribute to generation, but ſerve only to rear up their young.

I have before given my opinion of the principal uſe of this poiſon in the Bee, that is, I think it contributes to prepare what is called the Bee-bread into wax: this, however, requires to be yet more accurately inveſtigated. The whole ſting, nevertheleſs, great as it is, ſeems to be appointed only to do miſchief, and formed by nature ſolely for that purpoſe, that the Bees may, by the help of it, defend their young againſt the inſults of other creatures, and feed them in ſecurity. Since therefore the nouriſhing of the ſtock is committed to the common working Bees, hence it ſeems probable that they, particularly about the time of ſwarming, and a little after, are as furious and as much inclined to ſting and do miſchief with their poiſon, as they are eager to preſerve as well the iſſue committed to them, as their own proper food. It would not be improper to conclude from thence, that the ſting and the power of doing hurt with it, are given them on that account. The truth of this will be more evident to any one who conſiders that the females of the Hornets are likewiſe provided with ſuch weapons, though they never form any wax, but build their habitations principally, as it appears, of the bark of trees faſtened together. Hence various colours are obſerved in their neſts, according to the variety of the bark of trees which they have uſed in building them. We likewiſe ſee in the time of copulation with what fury the Stag ſtorms and rages if any one comes near him: this Harvey very accurately deſcribes from experience. Nay, even the otherwiſe inoffenſive domeſtic fowls will fly in the face of thoſe who endeavour to take away their young, and even Bitches and Cats, however mild and gentle they are, yet cannot endure to have their whelps and kittens touched. Theſe are the arguments which nature ſupplies for eſtabliſhing the uſe of the poiſon. But that the poiſon, in preference to any thing elſe, is given to theſe inſects with deſign to hurt mankind and all other animals by it, and that their ſting alſo, as ſome think, is made to torment and harraſs the human ſpecies for the hereditary ſtain of mortal ſin, is moſt abſurd, and plainly contrary to the infinite goodneſs of God: he does not vex or torment but kindly chaſtiſes, unleſs when the number of their ſins voluntarily committed are increaſed beyond all meaſure. I ſhall here conclude this diſſertation on the working Bee, ſince it is not granted to us to ſearch perfectly into the divine works with our limited ſhallow underſtandings *. I have propoſed the matter, and with my own hands deſcribed and delineated the ſituation, ſtructure and uſe of their parts,

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* The Bee has been honoured with the notice of philoſophers from the earlieſt time. What Virgil has ſaid of this inſect is principally from Ariſtotle. Theophraſtus has alſo wrote expreſsly on them, and we read of a greek naturaliſt who retired from human kind, and paſſed a long time in the woods to obſerve them. But the labours of all theſe anſwered little purpoſe: it is not till very lately that we have underſtood their nature, and we owe more to Swammerdam than to any one author in this inquiry.

parts; and therefore theſe various obſervations may be of uſe to us, until it pleaſes God to throw more light on our knowledge of the ſubject; for in this way we may at length moſt eaſily know the Architect of nature, from whom we are the further removed, the further we proceed, if we only indulge our own vain reaſonings.

The order I have preſcribed to myſelf requires that I ſhould now exhibit the anatomy of the female Bee: I ſay, the female, which, as it is a diſtinct inſect found in the hive, ſo it is by a common error generally dignified with the glorious title of king, though by ſome it is more properly called the Mother-Bee. I ſhall endeavour to follow ſuch a method in this hiſtory, that, as the female has many parts in common with the working Bee, I ſhall only deſcribe thoſe which that kind has not, together with ſome others, which I have obſerved more clearly in the female. Among theſe I mention in the firſt place, the heart. Tab. XIX. fig. I. *a a*. This is a tube pretty ſtrong and fibrous, it is oblong, and here and there dilated, it is extended in length from one end of the body to the other, and then turning about, it paſſes through the narrow little part or horny tube, which, like a thin filament connects the breaſt with the belly. In order to diſcover the heart in the abdomen, as in that part it may be beſt ſeen, it is neceſſary to diſſect or lay open the horny rings of the body with ſciſſors or a knife, taking care at the ſame time not to hurt any of the parts that are under theſe rings; for the outermoſt part of the rings of the body is ſo thin and tender, that not only the pulmonary tubes may be ſeen tranſparent through them, but one may alſo diſtinguiſh, though obſcurely, the motion of the heart under it. The pulmonary tubes in the female are not ſo frequently divided or expanded into bladders as in the working Bees, which difference is ſo ordered by nature, that the working Bees may fly the more conveniently and expeditiouſly; whereas the female is underſtood to fly but once a year, that is, when they ſwarm. However, I cannot entirely agree with this tradition, but rather think the female goes out of the hive in fair weather, in order to breathe a purer air. It muſt be obſerved, with reſpect to the diſſection of the body, that its rings are at their origination of a full rediſh brown colour; but of a yellowiſh red where they become membranaceous. In the midſt of them are ſeen two or three blackiſh lines, and the extremities of the rings grow black again, and are very thin, and provided with a horny verge. This obtains only in the lower parts. If the upper part of the ring of the abdomen be broken and carefully raiſed up, as I have before adviſed, the heart, Tab. XIX. fig. I. *a a*, immediately comes in ſight, and appears to be ſituated in the uppermoſt region of the abdomen, and is furniſhed with many ſmall and delicate air-pipes *b b b*, which iſſue from each ſide, and are inſerted in the ſubſtance of the heart. Theſe air-pipes or pulmonary tubes are ſupported by ſome tender and very delicate membranes *c c c c c*, which keep the fat that lines all *d d* about and underneath them in its place. Through theſe little membranes, and on each ſide of them, in ſome places, a ſubjacent ovary *e e e* is found to ſhew itſelf. If the diſſection be made in the manner I have directed, about the fat of the little membranes that connect the extremities, there will be ſeen alſo ſome muſcular fibres, broken off from the rings of the abdomen, which ſerve to move the muſcles *f f f f f*. Under the ſections alſo, between the fat, ſome muſcular fibres preſent themſelves, which ſeem to contribute very powerfully to dilate and conſtringe the heart, and at ſome times to puſh the air through the compreſſed pulmonary pipes towards the heart. Even the membranous fibre which connects the fat, likewiſe embraces the whole ovary underneath, which by this means comes in view; when that membrane is carefully cut, the heart removed, and the great number of pulmonary tubes which are connected with the ovary and heart, and this membrane and the fat are removed. The numbers Tab. XIX. fig. 1, 1, 2, 3, 4, 5, 6, denote the rings of the abdomen, under which, as in the back, the heart is ſituated.

The greateſt part of the ovary is lodged in the uppermoſt region of the abdomen, and ſtands as a partition between that part and the breaſt, ſo that the other viſcera, that is the ſtomach, inteſtines, vaſa crocea, or yellow veſſels, and others, are placed much lower in the body.

The ovary is divided into two parts, fig. III. *a c*, in the ſame manner as it is in the human ſpecies, in quadrupeds, fiſh, and many other ſpecies of inſects, and even in frogs. Theſe parts of the ovary are more or leſs ſeparated from each other in thoſe different animals, but here they lie contiguous to one another; one part indeed is placed in the right, another in the left ſide of the abdomen; beſides, the ovary here is ſo firmly connected by the pulmonary tubes that run through it, that it cannot without difficulty be ſeparated.

The ovary appears to the eye as a membranaceous little part, ſo wonderfully delicate and tender, that the containing membranes are ſcarce any hindrance or impediment to the encloſed eggs being diſtinctly ſeen through them.

The ovary, as I have obſerved, is divided into two parts, and each of them is again ſubdivided into two ſingle parts, which, for diſtinction's ſake, may be called the oviducts, though they in reality conſtitute the ovary itſelf, and give to the eggs which lie in their cavities both coats and ſubſtance, and whatever elſe belongs to their nature. This, however, is otherwiſe in birds and ſome of the quadrupedes. In the larger animals, and in the human ſpecies, there is obſerved a conſiderable difference as to this matter; for the human ſpecies, as alſo quadrupeds, Cows, Sheep, Dogs, Cats, Rabbits, and the like, acquires their full perfection in the ovary, and are from thence afterwards conveyed through a paſſage made for that purpoſe only, the fallopian tube, at once into the uterus, nor do they ſuffer any change in all this journey. In Birds, on the contrary, the egg is but half perfected in the ovary, the yolk only being formed there; but the white and ſhell is afterwards added to this in the oviduct called their uterus. In ſome quadrupedes, as Frogs, the whole animal, which appears at firſt in the form of a round egg, acquires its full perfection in the ovary, but it is afterwards covered over in the oviduct or tube, with a viſcous matter, with which it deſcends into a kind of hollow encloſed membrane, which is their uterus: this viſcous matter is the firſt food the animal ſwallows. In Bees the egg obtains its beginning and perfection in the ovary, which performs the office of an oviduct, tube, and uterus or womb, all in one. This ovary appears to the obſerver at firſt like a ſmall and ſimply membranaceous tube; but in reality there is a neceſſity for much more apparatus. But our imperfect reſearches can go no further than our eye-ſight reaches.

Behold, then, after what manner the omnipotent Architect hath retrenched, as it were, ſeveral parts here from the uſual oeconomy of nature, and contracted them into one!

In the Silk-worm's Butterfly, the ovary is in this manner alſo divided into two parts, and each of them again divided into four others, which I call oviducts, whoſe ends or extremities are of a ſimilar ſtructure with thoſe of Bees. In the Rhinoceros Beetle alſo the ovary is in the ſame manner divided into two parts, each of which is again divided into ſix oviducts. In the Humble Bee I found each ſide of the ovary ſeparated into four parts. In the Waſp, which lays more eggs than the Humble Bee, I ſaw the ovary, Tab. XIX. fig. IV. *a a*, divided on each ſide into ſeven oviducts. But here in the female Bee ſo many oviducts occurred, that I was not able to reckon them; for not only the great number of the diviſions prevent the counting them, but alſo the extreme tenderneſs of the texture; whereby they are very eaſily deſtroyed under our hands: to this may be added the very ſtrong knots, by which the pulmonary tubes bind theſe oviducts to them. Nor could I any more reckon how many eggs there were in each of theſe oviducts; but this is very eaſily done in the Humble Bee, in whoſe oviduct I computed ten larger, and ſome ſmaller eggs. In the Silk-worm Butterfly I have ſometimes counted ſixty or ſeventy eggs in each oviduct; but in the Bee I could by no means determine the number of the eggs: in another ovary I counted ſixteen or ſeventeen large and ſmall eggs in one duct; ſo that the Bee has a ſmaller number of eggs in each oviduct, than the Silk-worm Butterfly. I afterwards attempted to count the oviducts in another female; but here again I had as little ſucceſs, both on account of the ſtrong connexions of the parts one with another, as becauſe I could not ſpare the neceſſary time. Upon comparing the numerous oviducts, which I had found with the greateſt labour, with thoſe in the other part of the ovary, which I had not computed, I think I may venture to affirm that there were more than three hundred oviducts in the ovary of the Bee. And hence, if this number of 300 oviducts be multiplied by the number 17, (for there were ſo many diſtinctly viſible eggs in one oviduct, when the female was entirely perfect,) it will reſult from the whole, that there are five thouſand and one hundred viſible eggs in one female Bee, and yet theſe ſo different from each other in ſize, that one would be ſurpriſed; for thoſe that are to be laid laſt, are no more than rudiments ſo ſmall as to eſcape not only the eyes, but even my beſt microſcope, and are to be numbered by Him alone who formed them. The extreme points or ends of the ovary, which contain theſe minute eggs, are placed in the uppermoſt and higheſt region of the belly, and are there as it were folded and turned back. The ſame thing is ſeen in the Humble Bee, and Waſp, and alſo in the Silkworm Butterfly; but in the Waſp the ovary terminates in wonderfully long productions, Tab. XIX. fig. IV. *b b b*, which are ſo interwoven with the pulmonary tubes, that one would think them a little net compoſed only of thoſe tubes. It is to be obſerved that I here repreſent a double ovary, and that one of its ſides, fig. III. *a*, is taken out of a fully pregnant female; the other out of one *c* not ſo far gone: and hence a great difference ariſes in the form of the ovary. The eggs, *f f*, *i i i*, which are repreſented in the extremity of the Bee's oviduct, that was not ſo far gone in her pregnancy, are by far more numerous, ſmaller, paler, ſhorter, and more oval, as alſo more pellucid and tender than thoſe which are ſituated in the lower part of the oviduct; out of which the eggs finally iſſue and are produced. This is conducted in the ſame manner by nature in other inſects, I have obſerved it in the ovary of the Louſe, but in the ovary of the Frog all the eggs are of the ſame ſize: in the human ſpecies, in quadrupedes, and birds, they always differ in magnitude. And it muſt be here obſerved, that in the ovary of the leſs forward female, ſome eggs appear larger than others, fig. III. *l l l l*; though they be already come down to the lower parts of the ovary. But this, as I have obſerved, I never ſaw except in females, which did not increaſe their colony as they ſhould have done, and when there was ſome confuſion in the hive: therefore I really think that the female's ovary has then ſome ſpecies of a diſorder. And hence I have, in order to prevent the neceſſity of two figures, on one ſide *a* delineated part of the ovary of the real pregnant female Bee; for thoſe are now called queens or females by our Bee-keepers, which enrich the hive with a numerous off-ſpring, and plenty of wax and honey; and it is there obſerved that the eggs *g g*, *h h*, are almoſt all of a ſize, and by degrees decreaſe the higher they are ſituated. The extreme ends of the oviducts reſemble in the real prolific Bee *f f*, delicate, fine and ſcarce viſible filaments, which are likewiſe crooked at their extremities, and are furniſhed with rudiments of oblong and almoſt equal eggs, which at laſt become ſcarcely viſible.

Where the ovary is more protended or ſtretched downwards in the lower region of the abdomen, it there terminates in two very conſiderable ducts *b b*, *n n*, which reſemble the two cornua or horns of the uterus in quadrupedes. All the other oviducts open into them, and bring their eggs thither, which is the caſe not only in the true female prolific Bee, but alſo in the others, though in a leſs regular manner. Theſe two ducts are dilated by degrees, and become ſo conſiderably larger; that they appear at length like a globular maſs *p p*; but when I opened them there, in the real prolific female, I found in each ſide nine or ten eggs *q q q q q*, which had deſcended ſo far, and are there probably covered with a ſtronger coat or tunic, or are changed and prepared in ſome other manner, ſo that they may be afterwards emitted with ſafety out of body; for the Bees do not lay their eggs as they naturally fall, like hens, but ſet them upright. Theſe eggs, Tab. XIX. fig. III. *q q q q q*, here likewiſe appear though faintly through theſe horns of the womb if it be proper to give them that name. For the uterus or ovary is in that part fibrous or muſcular, and therefore is of a proper texture to puſh the eggs forward, and expel them out of the body; nor do I doubt but the oviducts have alſo ſome muſcular fibres. A little lower, near the extremity of the body, theſe two horns of the uterus become narrower again, and at length they unite in one canal, which is likewiſe fibrous, and has a kind of periſtaltic motion *ſ*. The ſpinal marrow paſſes through the extremity of this aperture, which is left between theſe two ducts near where they are to unite *o*, indeed juſt above the place where this union happens; and there give ſome nerves to the ducts, by the help of which they acquire a power of moving, and the inſect is enabled to diſcharge its eggs at its pleaſure. This is the method wherein the ſpinal marrow paſſes through the ducts of the ovary in Humble Bees, and the ſame is ſeen in Waſps. Many pulmonary tubes are alſo fixed into thoſe two horns of the uterus *r r r r r*, and the whole ovary is in like manner furniſhed with many ſuch pipes: it receives them on each ſide from the dilated pulmonary tubes, which are the pneumatic bladders or lungs of the Bee. I exhibit ſuch an oblong bladder *d* in one ſide, where the ovary of the not fully perfected Bee is exhibited, that it may be ſeen by what means that bladder tranſmits its ramifications into the part of the ovary ſituated on that ſide. Theſe pulmonary tubes are diſtributed through the whole ſurface of the ovary, but they are ſeen chiefly about the eggs themſelves: this I have repreſented in a very ſmall egg, as may be ſeen under the letter *b*, in fig. V. The egg is there delineated magnified together with all its pulmonary tubes. In the extremity of the body is afterwards ſeen a ſmall part exactly globular or ſpherical, fig. III. *t t*, containing a ſlimy matter in it, by means of which the ends of the eggs are faſtened in their waxen cells. About this globe part two other exuberant parts are to be obſerved, like crooked horns *u u* terminating in one foot-ſtalk or tube. Theſe are afterwards inſerted in the uterus. This tube draws the matter contained in the ſpherical particle out of it, Tab. XIX. fig. III. *t t*, and with this matter afterwards moiſtens the eggs that paſs through in order to be laid. Thoſe two veſſels *u u* have their extremities cloſed up, and ſeem to me to ſecrete the glutinous matter found in the ſpheric bag, and to depoſit it into the latter; unleſs the glue be rather ſecreted in the bag itſelf, which I rather believe. Theſe cloſed veſſels are likewiſe very remarkable in Humble Bees; but the bag has a different figure in that inſect. In the Hornet the bag is likewiſe ſpherical, as it is here in the Bee. In Waſps it is of a pear-ſhaped figure, fig. IV. *c*; but the cloſed veſſels, or thoſe which ſecrete the ſlime, if it be ſo, are not ſo large, or remarkable there as in the Humble Bees or Bees. In the Silk-worm Butterfly theſe veſſels are very conſpicuous, but there is no ſuch bag of ſlimy matter there. The ſpheric particle or the bag of ſlimy matter in the Bee, has two coats, the outermoſt whereof is whitiſh, muſcular, and in a wonderful and very beautiful manner interwoven with an infinite number of pulmonary tubes, ſo that one would ſay it was wrought with a needle. The outward coat may be eaſily taken off from the under one; and when this is done, that little part appears more exactly globular, and becomes of a faint purpliſh colour, variegated with white ſpots. If the inward coat, which is thicker and more glandulous than the former, be opened with a ſmall pair of ſciſſors, a turbid or thick moiſture flows out of it, which is like glue; it ſticks to the fingers, and may like ſilk be very eaſily ſpun out into threads, which immediately grow dry in the circumambient atmoſphere. By the help of this ſlimy matter the female Bee fixes its eggs in the cells: the Hornets and Waſps alſo glue their eggs ſo firmly in their places, that they cannot be afterwards removed without injuring them; but the eggs of the Humble Bees are not ſo firmly fixed. I have obſerved ſomething ſingular in theſe, and therefore I ſhall delineate the method whereby this fixing of them happens, after I have finiſhed the hiſtory of the female parts. The Silk-worm Butterflies likewiſe have their peculiar cloſed veſſels, which contain the ſlime that ſerves to fix their eggs. I have likewiſe obſerved the ſame thing in lice of the human head, which differ from thoſe of other animals greatly. Theſe have a conſiderable ovary, likewiſe divided into two parts, each of which is again divided into ſix oviducts containing a great number of eggs or nits. Theſe eggs likewiſe differ from each other in bigneſs, and when they approach to being laid, thoſe that are firſt laid and faſtened down are much larger than the latter ones: this is likewiſe the caſe in Waſps, whoſe eggs are ſmall and oval, Tab. XIX. fig. IV. *d d*. The bag of ſlime has, as I have obſerved, on the lower part or otherwiſe on its ſide, an oblong duct, by the help of which it is connected with the excretory paſſage of the eggs, fig. III. x, and therefore when the eggs paſs through their excretory paſſage in that part under the tube of the bag of ſlime, they are covered over with its ſlime, which makes one end of them afterwards, when they are diſcharged, adhere to the wax; but how or where the orifice of this excretory paſſage is χ, and what parts are to be ſeen there, I have not yet obſerved, ſince very few females are to be found in theſe unhappy times, whoſe wars and ſlaughters have deſtroyed even the Bees in our country: to this may be added, that what has been laid down cannot be ſeen ſo exactly, unleſs the hinder parts of the body of the Bee are taken out, which I would not attempt, becauſe the reſt of the parts were in this experiment to be preſerved; therefore I have nothing more to ſay on this ſubject. I ſhall only obſerve that the letters $y\ y$ indicate the external muſcular parts of the ſting, as naturally bent δ, when broke off. z Exhibits the poiſon bladder with its tube α, and cloſed appendages $\beta\ \beta$, and its tube γ, protended or ſtretched towards the ſheath of the ſting. ζ Repreſents the laſt gut called the rectum; all the parts before recited are here expreſſed in their natural form, but greatly magnified. There are likewiſe ſeen two little parts $\varepsilon\ \varepsilon$, wherewith the ſting is furniſhed on each ſide; theſe we have ſeen deſcribed in the hiſtory of the common working Bee, which has them in common with the female.

As to the ſtomach, inteſtines, vaſa crocea, or yellow veſſels, and other parts, all theſe are conſtructed in the ſame manner in the female, as I have before deſcribed them in the working Bee. I thought I obſerved ſome ſmall difference in reſpect to the colour, as well as ſtructure and ſituation, in theſe little oblong parts, which I examined in the cavity of the working Bee's inteſtine, where this is at length dilated.

The poiſon-bladder is likewiſe very remarkable in the female Bee, being throughout pellucid, clear, and perſpicuous like a diamond; it is as large again as in the working Bee. The tube, being conſpicuous in the hinder part of this bladder, may be more eaſily diſcovered here than in the working Bee: and the other tube which is extended from this bladder towards the caſe of the ſting, is alſo ſtronger and ſomewhat longer in this than in the working Bee, but as the humour contained in this bag appears to be ſo perſpicuous and agreeable to the ſight, I have endeavoured to taſte it, taking care at the ſame time that I ſhould not taſte ſo much of it as that it could do me harm. This liquor firſt affected the tongue with a bitteriſh taſte, which afterwards became more acrid and pungent, diffuſing itſelf through the whole cavity of the mouth unto the jaws, and forcing the ſaliva out of its ducts, and indeed the tongue was affected in the ſame manner, but leſs violently, as with the root of pellitory of Spain. There was likewiſe a great motion made by it in all parts of my mouth, as if I had taſted ten or twelve drops of the moſt highly rectified ſpirit of wine; after this, becoming more bold, I taſted the poiſon of other Bees, and of Waſps: all were alike, only that I diſcovered that the poiſon in the working Bee was not ſo vehement as in the female; and again, that what is in the female is more mild or gentle than the poiſon of the Waſp. What wonder is it that a very ſmall drop of this poiſon being violently driven between the ſkin and fleſh, and immediately mixed with the maſs of blood, ſhould produce ſo much pain, pulſation of the arteries, ſwelling and inflammation to that degree, that not only a fever, but death alſo would enſue thereon, if many ſtings were inflicted at once. If a ſmall piece of glaſs, or a little wooden ſplinter, be ſtruck or fixed in the finger, it cauſes the moſt violent pain, what muſt be expected therefore from this ſharp and moſt penetrating liquor, which corrodes at the ſame time, fixes itſelf violently in the parts, diſſolves their continuity, and at length creeping into the blood-veſſels, diffuſes itſelf, and circulates with the maſs of blood through the whole body? it is a common obſervation among the vulgar that ſix Hornets are ſufficient to kill a horſe.

The ſting, together with all its parts, is conſtructed in the female almoſt in the ſame manner as I have before deſcribed it in the working Bee; the only difference I obſerved was that it is more remarkably bent in the female, though at the ſame time it is very ſharp; this is probably the reaſon, that the female does not naturally wound with its ſting, nor can it do it eaſily: from this was afterwards framed the fable that the king, for ſo they called the female, has no ſting, and is of a mild diſpoſition. The female certainly threatens a ſtroke, at leaſt, when ſhe is provoked, as I have learned from experience. But what the real uſe of this poiſon is, if we are certain that it is given to Bees for ſome other purpoſe beſides that of defending their offspring, in doing which they loſe their lives, I ſcarce ſee how it is poſſible to diſcover. I formerly thought it might poſſibly ſerve to make the wax; but the Waſps and Hornets deſtroy this opinion, which are furniſhed with a ſting and poiſon, though they make no wax. Nor does the female Bee prepare any wax, nor even defend its young; ſo that this uſe alſo may be queſtioned or diſputed. Behold then, reader, how difficult it is to inveſtigate nature in her works, and learn with me, to cloſe your lips, and candidly confeſs our general ignorance and weakneſs.

The firſt obſervation on the female Bee.

THE better to illuſtrate what has been here advanced of the ſting and its poiſon, as alſo of the ovary, I ſhall add ſome particular obſervations, which I have ſince the writing the former account made on the female Bee. On the 16th of June I opened a hive, and I found in it ſeveral ſovereigns or females, which were ſoon after to ſwarm, yet lying covered in their waxen cells. Of this I was very certain, becauſe I found them with their skins caſt, and with expanded wings, nay they were ready to ariſe out of their cells. In the firſt of theſe which I diſſected, an ovary occurred, but was not very diſtinctly conſpicuous. I was obliged to make uſe of a powerful microſcope to examine it, but then I ſaw that there were numerous oviducts in it, and the eggs themſelves as it were innumerable on account of their ſmallneſs: I really think there were ten or twelve thouſand of them. I could diſtinctly have counted them, if I had had a mind to have undertaken the laborious office of ſeparating them from each other: the eggs themſelves, compared with thoſe which I had before obſerved in the female Bee, at the time ſhe is engaged in laying eggs were ſtill very ſmall, nay, thoſe which were in the extreme ends of the oviducts were ſo wonderfully minute, and ſo thick placed together, that I could not diſtinguiſh them, but by the help of my moſt powerful microſcope. I have likewiſe obſerved the ovary inveſted here as with a common membrane, which I confeſs I never before ſaw ſo diſtinctly.

The ſecond obſervation on the female Bee.

IN a ſimilar female Bee, produced at the ſame time, but more mature, which, with ſome thouſand of other Bees had ſwarmed out of its native hive, and was received into another, I ſaw that the ovary was likewiſe yet conſiderably ſmall, nor did even the eggs appear much larger, than if they were yet in their rudiments; and hence I concluded, that this female was but juſt excluded from her cell, when ſhe flew away in this ſwarm out of her native hive. I could not in that ſubject obſerve many remarkable things further, nor in others, though I had many females ready, for all of them died in the ſpace of one or two days. But though I threw them into ſpirit of wine to keep them from drying, yet many of the viſcera were, to my great concern, ſpoiled: the reaſon of which was probably becauſe I did not make uſe of a ſpirit ſufficiently rectified. I obſerved that the poiſon in ſome of them was converted to a white matter, nearly without taſte or ſtrength, which when expoſed to the air dried up and evaporated. In another I ſaw the poiſon ſeparated and condenſed into irregular white grains, and I could very diſtinctly ſee in that Bee the whole poiſon duct, which is connected with the hinder part of the poiſon-bladder, and which perhaps ſecretes the poiſon, covered over with coagulated particles of fat, which could not be eaſily wiped off.

The third obſervation on the female Bee.

I OBSERVED in another female, which I diſſected about the ſame time, that one of the extremities of the poiſon duct was ſubdivided into two other cloſed but ſhort appendages. When I meaſured the poiſon duct, from the bag to its firſt diviſion, I found it to be a quarter of an Holland inch long, and that one of the branches of this divided duct was almoſt half an inch long; and the other almoſt two inches. However, theſe things cannot be obſerved, unleſs one has firſt very cautiouſly ſeparated all the curvature and ſerpentine windings of theſe ducts from the reſt of the viſcera. Though this Bee had likewiſe lain in ſpirit of wine, yet all theſe parts were very diſtinctly conſpicuous and ſtrong in it.

The fourth obſervation on a prolific female Bee.

IN a truly prolific female Bee which had ſwarmed on the 24th of July, and had laid many eggs, I obſerved ten or eleven days after that I diſſected it, that the beginning of the ovary was furniſhed with a great number of perfect eggs; but the eggs that ſtill lay in the appendages of the oviducts, were not of that ſize or perfection which they are obſerved to have in the oviducts of the prolific Bees diſſected in the month of May, at which time they are moſtly employed in laying their eggs; nor were they ſo perfect as the eggs of the females examined in the months of autumn, as will be made evident in the fifth obſervation. From all this I diſcovered, that the female which had ſwarmed was young, and newly produced from her cell. But whether all thoſe that ſwarm are young, I cannot yet preſume to affirm for certain. Not only thoſe eggs which were in the lower part of the beginning of the oviducts, but thoſe which were ſituated higher had arrived to their perfect ſize. This ovary likewiſe had in it an infinite number of eggs, ſo that in only fourteen little parts which were broken off from the appendages of the oviducts, I reckoned one hundred and ſeventy four eggs. Hence it is not difficult to judge what a ſtupendous number of eggs one female contains. But there was a neceſſity for ſuch a formation and conſtruction, ſince a whole hoſt of Bees of all the three kinds were to proceed from one female, as is actually the caſe. This numerous family not only contains three, four, or five thouſand Bees, but ſometimes nineteen thouſand, as hath been obſerved elſewhere. I likewiſe in this ſubject diſtinctly ſaw all the oviducts on each ſide of the ovary unite in five principal branches, with which the reſt of the oviducts were connected, and through which each conveyed its eggs into the common ducts.

Notwithſtanding all the pains I took, I could not diſcover the orifice of the ovary or vulva in this Bee, becauſe I was in the country and had not all my inſtruments at hand, and becauſe I did not take the vulva out of the hinder parts of the body, fearing leſt I ſhould hurt any of the parts which I thought neceſſary to examine. However, I ſaw very diſtinctly that the excretory duct of the eggs, Tab. XIX. fig. III. *f*, where it approaches to the laſt ring of the body, dilates itſelf into a muſcular globule, and then growing narrower, at length becomes again wider and more membranous; but I could not proſecute this inquiry any further, becauſe I deſigned to keep unhurt the poiſon bag, which is ſituated in that part, together with ſome particular muſcles that belong to the ſeveral parts of the ſting. In another female I thought I obſerved that the orifice of the vulva, when the Bee lay on its belly, opened under the ſting in the laſt ring of the abdomen, and that it is very difficult to penetrate into this orifice, unleſs the parts be expanded and raiſed at the time the Bee is laying eggs. I likewiſe ſaw the fundament very plainly, and its orifice opening above the two appendages of the ſting: it was placed in reality juſt over the ſting and the two little parts juſt now mentioned. I further diſcovered that the rectum or ſtraight gut had a kind of cavity there, which was full of red and yellow excrements, but that the inteſtine itſelf was formed in the manner exhibited in Tab. XVIII. fig. I. letter *l*.

I have moreover obſerved that theſe two obtuſe appendages, which the aculeus has as it were for ornament *o o*, are in reality the productions of thoſe cartilages, which I have figured in Tab. XVIII. fig. II. *l l* and *m m*. But the true uſe of theſe appendages ſeemed to me to conſiſt in this, to try beforehand whether objects be ſoft or penetrable to the ſting, that the Bee may not in vain dart its ſting againſt harder bodies, and ſpoil it to no purpoſe. I obſerved alſo, that one ſide of theſe little parts was covered with a cartilaginous integument, and ſet round with fine hairs.

Since the ſting with all its parts was here in the female conſiderably larger than in the working Bee, I could therefore diſcover ſome ſingular things about it which I had never obſerved before. I firſt obſerved, that the ſheath itſelf of the ſting had two ſhanks, to which the ſhanks of the ſting itſelf were cloſely applied, ſo that the latter may by the help of the former, be more regularly moved. Theſe ſhanks of the ſheath were in this Bee alſo very beautifully bent like the ſhanks of the ſting. It is ſcarce credible how beautiful the ſtructure of theſe is near the ſheath; for there I obſerved likewiſe two ſmall parts, which being at their origin bent into an oval form, had a verge or border of a brown full red colour; but afterwards acquiring by degrees a paler tinge, and uniting in a point, they were on one ſide articulated with the cartilages before exhibited, Tab. XVIII. fig. I. *n n*, with which the extremities of the joints of the ſhanks of the ſting were likewiſe connected in the upper part. The little bone alſo, which I have before deſcribed to be like that in Birds, called ſpecillum, was obſerved to be articulated in the hinder part with the caſe or ſheath itſelf; but the poiſon duct paſſed there only higher up, and immediately terminated after it had advanced a little way in the ſheath. Whether all theſe ſeveral particulars be circumſtanced in the like manner in the working Bee, I have not yet examined.

I further learned from this diſſection, that the two little parts fig. III. *r r r*, which I have before exhibited in the common Bee, as ſituated on the outſide of the ſhanks of the ſting, were here in reality placed on the inſide of them. I likewiſe ſaw very diſtinctly, that the muſcles moving theſe ſhanks upwards out of the ſheath, and again drawing them downwards into it, lie in reality in the female between the margins of the ſheath in the hinder cavity of it, and are there inſerted in the two parts juſt now mentioned. Thus I at length found that theſe two little parts principally and chiefly contribute to keep the ſhanks of the ſting, whereof they contribute a part, in their places and prevent their ſlipping out of the ſheath; and this they can do more eaſily, as they themſelves are contained in the cavity of the caſe, out of which I have, with the aſſiſtance of a microſcope extracted them, and afterwards put them into it again without the leaſt hurt to any part.

I have likewiſe at length diſcovered the true reaſon why I had not before diſcovered in the working Bee what I have juſt now ſaid: and it was this, that the ſhanks of the ſting when drawn out of the ſheath, inſtantly bend themſelves, and hence it then happens that theſe two little parts always appear on the oppoſite ſide.

The fifth obſervation on a real prolific Bee.

IN a female Bee brought to me in autumn, at the time when the honey is taken from the hives and the wax alſo, and for which reaſon two hives are ſometimes then formed into one, I diſcovered the whole ovary to be ſtill full of innumerable eggs; ſo that I have from hence learned that the Bees never lay all their eggs together, as is the caſe with Hens, which commonly clear their ovary entirely, leaving only ſome ſmall rudiments behind. I therefore think, ſince the eggs in the ends of the oviducts of the Bee are innumerable, and lie diſpoſed in an delicate order, that they are continually diſcharged out of it, and ſucceed in the place of thoſe eggs which were before laid. In this female, which I preſerved for the ſpace of a whole year in ſpirit of wine; the poiſon was likewiſe coagulated and ſtuck in its bag like an oval particle of wax, but ſo as that the inward ſurface of the bag was ſeparated all round from the ſurface of the contained poiſon.

As I had many Bees at the time when theſe females were brought to me, I had an inclination to try what would be the conſequence if the poiſon was mixed with the Bee-bread. The following was the event of the experiment. The friable and otherwiſe very eaſily ſeparable Bee-bread, which is not naturally fit for working or kneading, nor is at all glutinous, was, by the admixture of the poiſon, inſenſibly rendered tenacious and clammy, and having loſt all its friability, began to melt in ſome degree at the fire, but it grew black after ſome time, exhibiting its former appearance of bread, which never catches the flame, but only grows black in the fire. The ſame maſs thrown into water was not diſſolved, but being ſomewhat agitated in the water, returned to its former diſpoſition, and at length began to melt. Some particles of Bee-bread kneaded or wrought with the poiſon, and kept fourteen days, retained their acquired tenacity, nor did they again become friable; but whether any thing can be inferred from this experiment I would not yet preſume to determine *. It ſeems at leaſt in ſome meaſure to follow from thence, that there is no reaſon to deny the Bee-bread, or that matter which the Bees carry fixed in their legs, and which is of a ſimilar nature with the Bee-bread, may be made into wax. But when I began this experiment, I had not the matter now mentioned at hand; nor could I get it, as the hives were carried at that time into ſome fields of buckwheat which was then in flames.

I have frequently offered the Bee-keepers a conſiderable preſent, if they would ſhew me real wax adhering to the legs of Bees: but though they readily undertook this, they never could perform it. Therefore the method whereby wax is made, muſt it ſeems yet be referred to or reckoned, amongſt thoſe things which we are hitherto ignorant of, and which ought to be inveſtigated. The ſame doubts may be raiſed concerning the making of honey, though this difficulty may be more eaſily removed. I have not hitherto been able to make all the experiments concerning this matter which I had deſigned. I ſhall therefore conclude theſe obſervations on the female, after I have firſt exhibited the manner of ſeeing diſtinctly how the Bees make the wax. For this purpoſe I ordered a wooden ſtool with three or four feet to be fitted into a ſtraw hive, in ſuch a manner that the hive might be conveniently taken off and again laid on it. I covered the edges of this ſtool with paper, and then in ſwarming time I put a new ſwarm into the hive. When I afterwards ſaw, that the Bees in the inſide had made wax and propagated young ones, which happen in ten or twelve days. I immediately removed the hive from that ſtool, and alſo took away the paper, and thus I could very diſtinctly ſee the Bees working in the ſun-ſhine. But though I have never gone through with this experiment, yet I know the effect of it, for I have often ſeen that the habitation of the Bees which had made their neſts in the holes of old walls and ruins of houſes, was a full ſquare foot wide at the mouth, through which their making of wax, and other operations might be ſeen conveniently. We ſhould not therefore fear that the Bees when expoſed thus openly will deſert the hive, which is the only objection that one can make againſt the propoſed experiment. The fear of their flying away will be the leſs, as they will have placed their offspring there before the operation, which they never afterwards relinquiſh. If any one ſhould fear leſt the Bees ſhould be injured by the nocturnal cold, he might cover them at night with a larger hive or any other larger cover. And in the day time they might be put in ſuch a place that they ſhould not be expoſed to the injuries of the heat or rain.

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* In fine weather the Bees conſtantly go out in ſearch of the matter of wax, which they collect from the antheræ of flowers. They eat ſome, and lay up the reſt in certain cells of the comb where it is preſſed down by other Bees, and this ſerves them to eat in bad weather, when they cannot go out. After they have ſwallowed this, and it has paſſed the operations of their ſtomach, it is wax, which they complete by more working and moulding; but though the farina of flowers be the real ſubſtance of wax, human art can never make wax from it.

I ſhall now proceed to the hiſtory of the male Bee; and here ſhall firſt briefly relate ſome things of Humble Bees and their eggs. The Humble Bees, as far as I have obſerved, do not build neſts or live together, but in the winter; like moſt other inſects they abſtain from food and motion, and therefore they are properly ſolitary Bees. I have ſeen, however, that about the end of May, or ſooner, ſome few male Humble Bees, and one female which is of a larger ſize, gather together in the paſtures and corn-fields about Amſterdam. The place they chooſe to build in is between the ſtalks of corn or graſs, and is not deep under the ſurface, but only a little hole burrowed under the graſs, in which hole there is found either naturally or heaped together by them, a tender ſoft ſort of down or moſs, on a ſmall part of which, formed in a kind of bed, with brown wax or a flexible matter like it, the female lays her eggs. With this matter alſo the eggs themſelves are all ſealed up underneath and on the ſides. But in what manner theſe eggs are depoſited there, and how the young and tender Worms creep out of them, and whether they eat this ſubſtance, I have not yet learned from experiments. I have lately however, namely, on the 22d of June this year found a perfect neſt, in one ſide, Tab. XXVI. fig. 1. *a*, of which there were eighteen cells, but in the other *b* only eight. Between theſe was ſeen one cell entirely empty *c*; and there occured in ſeveral places here and there *d e f* ſome particles of the ſame kind of waxy matter: in this the eggs were all cloſed up. I ſhall now diſtinctly deſcribe what I could obſerve upon this occaſion. I found one female and ſeveral males in this neſt, all which ſhewed by their humming and their running anxiouſly up and down, that my curioſity was by no means pleaſing to them. When I afterwards carefully viewed eighteen cells, and opened them by cutting off the piece *g*, I found them all full of little Worms, which were to be transformed into Nymphs *h*. Upon obſerving the ſtructure and ſubſtance of theſe cells, I found that they were all compoſed of threads or filaments, and were of an oval figure, and of a colour ſomewhat approaching to yellow. This I looked upon as a ſtrong argument that theſe little cells were not made by the Humble Bees, but by the Worms themſelves: nay, a certain, though not very exact order, was obſerved in their compoſition, ſince one cell was placed in the middle and ſurrounded by five others. They were all faſtened together in the ſame manner in which the Silk-Worm is accuſtomed to affix itſelf to paper or wax, by the help of her threads. And one of them was more elevated, another more depreſſed; on the lower part where they reſted on the down or moſs, they had contracted ſome dirt or mouldineſs, by reaſon of the dampneſs of the ſoil. I drew ſome of the Worms that lay on the inſide out of them and left others. And I found that thoſe which I had left in their cells, were in ſome days changed into Nymphs, and theſe afterwards in two or three weeks into Humble-Bees: theſe however did not creep out of their webs, but died in them, together with the Worms that I had drawn from thence. The eight cells of the other ſide did not appear to be made of this waxy matter: their figure was likewiſe leſs regular and orderly, and I therefore imagine they were made by the Humble Bees themſelves; but as I thought that honey or Bee-bread might be found in them, I indeed greatly admired, when I found only Worms of various ſize, and all cloſed up. In each of two of theſe cells I found two large Worms *i*, and in another only one *k*, but this was much larger. Theſe Worms taken from thence and put into a cornet of paper, covered themſelves with a web of an oval figure, and in the mean time diſcharged a large quantity of brown regular excrements, divided into equal parts, and very like the matter wherein they were depoſited. In another cell I found a waxen partition *l*, and in one of the apartments thus ſeparated were two ſmall Worms, and in the other two that were ſomewhat larger. I likewiſe afterwards found in another cell three Worms *m*, and in another four *n*. From what has been here ſaid, it is ſufficiently evident how greatly this cohabitation of the Humble Bees is different not only from that of the common Bees, but alſo from the neſts of the Hornets and Waſps, which are made by theſe inſects themſelves, and are admirably conſtructed. But what ſeems to me moſt wonderful of all is, that theſe Worms of the Humble-Bees which ſhould ſtill be in a ſtate of nouriſhing, are really ſealed up and covered with the waxy ſubſtance. Perhaps it may not be improper to conclude from hence, that theſe Worms uſe that matter wherein I found them covered, in the place of other food, and that the parent Humble Bees when the firſt quantity is conſumed, again lay another new parcel over them. This is in ſome meaſure the caſe in ſome Worms, which being depoſited in cheeſe, fleſh, fruit and plants, lie as it were covered up in their food or nouriſhment; for thoſe protuberances and knots, wherewith the whole inſect is covered, riſe in excreſcences, in plants and fruits, in the ſame manner as the Worms in cheeſe and fleſh, at length intirely encloſe themſelves in thoſe aliments. And hence it is very probable, that theſe Humble Bee Worms likewiſe feed on the wax wherewith they are covered and ſurrounded, nearly in the ſame manner as the Wolf-Caterpillar uſes the wax for food, and ſupports life: this I ſhall hereafter deſcribe in its place. Otherwiſe it would be neceſſary that the Humble Bees ſhould, in order to nouriſh their Worms, continually open and again cloſe up theſe cells, which would be a work of tedious and needleſs labour, ſuch as cannot be any where found in the works of nature, which are every where perfectly ſimple. The method of nouriſhment I have ſuppoſed becomes more probable, if we conſider the order in which the Humble Bees encloſe their eggs in this matter; for I do not think it poſſible that the Humble Bees can ſo exactly know the time when the Worms are to be excluded from the eggs, and when theſe cells ſhould be opened, becauſe they may be in want of food. To this may be added, that the matter wherewith the eggs are covered, can ſcarce be torn open any way without hurting them: but I ſhall leave this matter in uncertainty, until repeated and more ſucceſsful examinations determine it. That I may proceed in my intended ed method, I ſhall obſerve here, that I likewiſe ſaw an empty cell in this neſt. This was likewiſe made of filaments or threads, and it ſeems to me probable that a young Humble Bee had crept out of it. At length I alſo broke thoſe irregular particles of wax, which were in divers places found affixed to the woven cells of the Humble Bees: in one of theſe I found ſix eggs, Tab. XXVI. fig. 1. *d*, in a ſecond ſeventeen *e*, and in the laſt twenty-three *f*. Theſe eggs were pretty large, ſomewhat crooked, and were faſtened to the pointed extremity of the ſubſtance on which they were placed. When they were viewed with a microſcope, they appeared like that kind of rough skin which we call ſhagreen. They were of a milk white colour, and full of moiſture, and they all ſtood erect and ſo near each other, that they were almoſt contiguous; this made a very beautiful appearance. I a long time preſerved them as well within as out of the matter wherein they were encloſed, but they grew dry in the mean time, nor were any Worms hatched from them. Many Lice of unequal ſize, and which are very tenacious of life, crawl upon the Humble Bees themſelves. I obſerve alſo, that the Ants, and almoſt all other inſects, are tormented with their reſpective Lice. Goedaert calls theſe Lice the Humble Bees excitatores or provokers, and has invented ſeveral amuſing ſtories concerning them, but he relates a fable rather than a true hiſtory.

It is time we now deſcribe the parts of the male Bee. I ſhall here follow the ſame method I obſerved in the hiſtory of the female, and ſhall deſcribe only thoſe parts of the head, breaſt and body, which either are not in the working Bee, or are ſeen plainer and more perfect in the male.

About the head are principally to be conſidered the eyes, horns, teeth, and the feather-like hairs, wherewith the head is every where covered. I have already elſewhere treated of ſome of theſe parts; therefore I ſhall now deſcribe the eyes, in which the following particulars are to be obſerved on the in and outſide: the number of the eyes; the external figure; the hairs fixed on their upper part; the tunica cornea, and the uvea; the internal pyramidal and inverted fibres; the pulmonary tubes which run between theſe firſt and ſecond membranes, wherein the pyramidal fibres terminate; the tranſverſe cortical fibres, conſpicuous under theſe membranes; the cortical ſubſtance of the brain, ſituated under thoſe fibres; the brain itſelf with the three ſingular eyes over it; the origination of the ſpinal marrow juſt under it; the origins of the pulmonary tubes; and laſtly, the internal ſurface of the eye.

As to the number of eyes, there are here two principal or large ones, one in each ſide of the head; and beſide theſe three ſingular ſmall eyes which are here in the male, Tab. XX. fig. 1. *a*, in a triangular form between and below the larger eyes, in that part where theſe larger eyes are contiguous to, and again diverge from each other in form of the letter Y. In the females and working Bees, as has been obſerved before, theſe three eyes are ſituated higher up in the head, and lie pretty exactly between two larger eyes. But I ſhall ſay ſomething more of this matter hereafter.

The two larger eyes reſemble as it were a creſcent, with this difference, that in the upper on the head they are ſharp-pointed, but ſomewhat rounded *b b*; towards the lower parts *c* near the teeth, they again meet in a point. They are in form like a ſegment cut from a flattiſh rounded maſs, one ſide whereof is ſomewhat acute, and hollowed or bent inwards, and the other converges in a crooked form. In the upper part of the head toward the neck and back, theſe eyes are contiguous in their convex extuberant part, which is not the caſe in the two other kinds of Bees: but they again, on the lower part toward the teeth, where they become ſtill more acute *c*, conſiderably diverge from each other on each ſide; the ſmaller eyes, the horns, which are here ſevered *f f*, the teeth as they are called, and ſome feather-like hairs *d* being ſituated in the intermediate ſpace.

Both the eyes are alſo very thick covered with hair *e e e*, which, in order to avoid confuſion, I here repreſent only on one ſide. Theſe hairs ſerve the eyes inſtead of eye-brows or eye-laſhes; but becauſe their ſituation cannot be exactly underſtood, until after that coat of the eye which ſupports them is deſcribed, I ſhall therefore now firſt treat of that coat, the cornea, in which theſe hairs take root.

The outmoſt coat of the Bee's eyes, is the cornea; by which name authors have likewiſe called this ſame tunic or coat of the eye in man, and in quadrupedes, birds, fiſhes, and ſerpents. This appellation is more particularly appropriated to this tunic, ſince by its ſtiffneſs, hardneſs, flexibility, and clearneſs, it approaches to the nature of horn. The eye of the Bee differs, however, from that of men and other animals, in that as the cornea appears in theſe ſmooth and equally poliſhed, it is in Bees and in all other inſects that I have examined, divided by various and manifold diviſions: and as theſe diviſions reſemble globules or little ſpheres, hence it is that ſome ſubtile and ſagacious geniuſes, among whom may be reckoned the illuſtrious Dr. Hooke, believed that the inſect's eye was only a congeries of innumerable little eyes, each of which, in reſpect to its ſtructure, agreed with our eyes and thoſe of other animals: this ſtructure of the eye, however, I have not hitherto ſeen in any inſect but in the Snail, which on one ſide exhibits two diſtinct eyes, furniſhed each with its three proper humours. In order to explain the diviſions of the cornea in Bees a little more accurately, I would have it obſerved that they are by no means ſpherical, but rather hexagonal, Tab. XX. fig. 11. *k k*; but notwithſtanding this the maſſes themſelves are on the upper ſurface perfectly rounded, and conſequently exactly like the ſealed cells of the Bee; which being likewiſe circumſcribed by ſix ſides, yet riſe convex, and ſwell up in a globular ſurface, or are as it were arched. The woven cells of Hornets much more accurately expreſs this conſtruction of the cornea in the eye: for theſe have alſo ſix ſides, and are very beautifully encloſed in an arched or ſpheric web. The eye of the Bee, and moſt other perfect inſects, conſidered in this light, is really like a little net; which appears moſt perfectly when examined in the light by a microſcope: for then the moſt obſcure or opaque hexagonal interſections appear in the form of a net to any perſon who looks through the ſpherical tops of the diviſions. We muſt further obſerve here that theſe hexangular diviſions *k k* of the cornea, upon a more exact compariſon, do not perfectly keep the reſemblance of one of the cloſed up cells in the comb; for the lines which diſtinguiſh the cells of the comb from each other, are upright or ſtraight, whereas the hexagonal diviſions, on the contrary, which occur here in the Bee's eye, are intercepted by crooked and ſinuated lines. To obtain this form for them, the all-wiſe Author of nature makes uſe of the following means; that is, he gave the cornea a ſpherical convexity, by means of which ſome of the lines, together with their diviſions, are here and there broke off; and at the ſame time He alſo placed *k k* an hexagonal diviſion between ſix other diviſions of this kind: hence it is, that theſe hexangular diviſions appear as it were oval or arched, as I have in ſome ſort delineated between the annexed letters, Tab. XX. fig. 1. *c*, *eee*, *bb*. And in what manner every hexagonal diviſion is ſurrounded with ſix others, may be ſeen magnified under the letters *k k*, fig. 11. Some curious perſons, to whom I ſhewed theſe, were of opinion, that in the ſtructure of the eyes reaſons might be found why the Bees make their cells hexagonal; that is, becauſe they exerciſe the ſenſe of viſion by hexagonal eyes. Behold, how far we are led away by fictions, when, being ignorant of the foundations of things, we follow our vain fancy as a guide! It would be as natural to ſay we ſhould build only round houſes, becauſe the pupil of our eyes is of that figure. I have not yet counted how many diviſions there are in the Bee's cornea, nor do I know any method of doing it, unleſs one could cut the cornea into ſmall pieces, and afterwards count the diviſions in them ſingly by the help of a microſcope; obſerving at the ſame time that every two of theſe cut diviſions are to be reputed only one. However this matter be, the accurate Dr. Hooke hath computed in the eye of the Perla of Mouffet, which he calls in his own language Dragon-Flies, but in the Dutch language Romboud, Puyſtebyter, Naeyer, and Glaſeſchryver, fourteen thouſand ſuch interſections; this is indeed a great number. To this we may add, that theſe diviſions are ſo beautiful, ſo regular, and formed with ſo much art, that it by many degrees ſurpaſſes the moſt exquiſite human workmanſhip. Indeed, could any one think this could be done by human powers? ſince we cannot ſeparate or divide thoſe things which nature formed only as it were in ſport. This is the external form of the more than ſtupendous cornea of the Bee's eye.

As to the internal ſtructure of the cornea, it is divided within juſt into ſo many hexagonal little holes, or as it were round ſpoons, as on the outſide it is geometrically diſtinguiſhed into hexagonal ſpheres. But if this cornea, turned to the light, be viewed with a good microſcope in the manner before deſcribed, then at length its true and delicate hexagonal reticulation may be finely obſerved: for as the cornea is very pellucid and thin where it is hollowed or excavated into theſe little ſpheres, but conſiderably thicker where it is interſected; hence it happens, that the interſections only ſeem to ſhew themſelves to a perſon who looks through them: and this is the true reaſon why the cornea then exhibits itſelf like a net pierced by ſmall hexagonal apertures. But its ſurface is not always the ſame; ſometimes it appears divided into triangular, and ſometimes into quadrangular figures: this diverſity muſt be attributed to the variety of reflexions which the rays of light occaſionally produce in their paſſage. This obtains principally when the angles of the diviſions of the cornea are not all directly under the microſcope,

ſcope, for then only one part of the convexities can be ſeen, and the other not at all; and thus falſe angles are exhibited. Almoſt all concave bodies, if viewed in the light, appear to our ſight ſometimes globular, and ſometimes roundiſh and convex: this is illuſtrated very particularly by the engraved agats. For this reaſon the greateſt circumſpection muſt be always uſed in viewing objects by microſcopes, leſt we ſhould deceive ourſelves, which has commonly happened on theſe occaſions. I ſhall hereafter explain what produces theſe hexangular diviſions in this net of the eye. The thickneſs of the cornea in the Bee is pretty conſiderable, and indeed more ſo, conſidering its ſize, than in many other inſects which are equally ſmall: this may in ſome meaſure be comprehended from a ſmall piece of it delineated as it appears under the microſcope at the letters *lll*, Tab. XX. fig. III. Between the diviſions we have been hitherto deſcribing, are placed thoſe hairs which I have before ſaid are planted all over the eye. They are very firmly fixed to the cornea, for they pierce it all through in the ſame manner as our hair does skin: but they riſe ſharp-pointed, and are three or four times longer than the diameter of any one hexagonal diviſion: in ſtructure they reſemble briſtles, and are of a round figure, thick below and ſharp above. Their number is likewiſe very conſiderable, though leſs than the number of the diviſions; they are, however, ſo thick and ſo cloſe ſet together, that they ſeem to conſtitute a very cloſe foreſt of briſtles, like ſo many fir-trees planted upon the eye: this may be ſeen in ſome meaſure under the letters *eee*, fig. I. where I have repreſented them only in the circumference of the diviſions of the eye: of the other diviſions that are exhibited in the ſame figure, I have delineated a leſs and determinate number, they being very numerous, and hitherto beyond any account I have taken. Finally, I ſhould think theſe hairs are principally fixed here to guard the eye againſt any thing falling on, or ſtriking againſt it; to keep off the duſt, and, in caſe any of theſe annoyances ſhould ſlip in, to aſſiſt the Bees to throw, or bruſh it out the more eaſily, by a friction, which the Bees perform with their feathered legs: Flies alſo uſe the ſame method to wipe themſelves. Theſe hairs ſeem alſo to ſerve the Bees inſtead of eye-brows or eye-laſhes. I had firſt thought that only the long-lived ſpecies of inſects, ſuch as Bees, had theſe hairs: but I afterwards obſerved that they are not ſo peculiar to the Bees, as not to be found in many other ſpecies of inſects. I have found them among others in the coloured diurnal Butterfly: I have likewiſe found them on the eye of Goedaert his Bee. This eye, however, is not covered all round with theſe hairs, but only ſhews the oval orbit planted with them. Goedaert deſcribes the Bee I have juſt mentioned, in the ſecond experiment in his firſt part; but if any one examines this more accurately, he will find it is only a dunghill Fly, with no more than two wings, and conſtantly produced or generated annually in the ſame manner. It is produced from a Worm with a long tail and very ſhort legs, found in dunghills and common-ſhores, and belongs to the fourth order of our natural tranſmutations. The Bee, on the contrary, is to be ranked in the third order, as I have already ſufficiently proved. I ſhall proceed to deſcribe the uvea, which is the other coat of the Bee's eye. Of the other three remarkable little eyes I ſhall treat at large hereafter.

When the cornea is removed from the internal parts of the eye, the tunica or coat, underſtood to be the uvea, comes in view. This, therefore, is not placed in inſects at the bottom of the eye, but next to the ſurface; nor does it any where appear perforated as in large animals. This conſequently prevents the rays of light penetrating further into the eye than through the cornea only. When the cornea is taken from the eye, we uſually ſee that a more opaque matter, which entirely takes away the perſpicuity or clearneſs of the cornea, is carried off with it. This matter is of different colours in different animals; in Bees it is of a deep purple, in other inſects it is green, in ſome blue, in others black, and in others again it has a very beautiful mixture of various colours, which are elegantly and agreeably ſeen through the cornea. But this is to be found only in the inner ſurface of the cornea, where the uvea adheres next that coat, without any thing between. The two parts of this matter which conſtitutes the uvea, both that which is applied to the inner cavity of the cornea, and that alſo which is obſerved to adhere to the internal parts of the eye, are commonly of a blackiſh colour, and the laſt likewiſe ſtains the fingers when touched, and is a kind of black paint, as our uvea and that of other animals is: and hence it ariſes, as I have before obſerved, that the perſpicuity of the cornea is darkened or obſcured by this matter. Therefore, in order to ſhew the cornea pellucid, this matter muſt be firſt wiped off with the help of a pencil or a ſmall piece of paper folded up. If you preſs the head of the Fly between two folds of paper, the paper acquires a purple colour from it, which is owing to the more diffuſed colour of the uvea. But perhaps ſome one will aſk, if the matter hitherto deſcribed ſeems only to be the uvea, but is not ſo in reality, what is it? To this I anſwer, that this matter is nothing but the tops of ſome broken fibres, which are placed cloſe under the cornea, Tab. XX. fig. I. *gg*: for no humours, properly ſo called, are found in any part of the Bee's eye, which is a thing well worth obſerving: though the celebrated Dr. Hooke, for want of a ſufficient number of experiments, hath been led to imagine there were ſuch in the eye of the Libella; becauſe no other method occurred to him, by which the ſight of inſects could be explained. However this matter be, the coloured part of the Bee's eye, though it be not an uvea, ſerves the uſe of that coat in the eyes of larger animals.

Immediately then under this uvea, as it has been called, are ſeen ſo many fibres, as there are diviſions above in the cornea. Theſe fibres very exactly agree with the cavities of the ſpherical diviſions of the cornea: and they are likewiſe hexagonal and broad, but thiner in the middle and ſharp-pointed underneath where they terminate. They are all nearly of equal length, thickneſs, and breadth. But above the margins and extreme ſinews of the eye, theſe fibres are ſomewhat bent and ſeem ſhorter: they are above, where they are joined to the diviſions of the cornea, much thicker *h h* than below *i*, where they are only united together by their ends: and hence they almoſt reſemble ſo many inverted ſexangular pyramids, thick and broad above, and thin and acute below. In order to conſtitute the convexity or arch of the eye, they are placed together in the manner of thoſe eggs of inſects which are circularly glued round the branches of trees. Theſe fibres ſtand erect on the bottom of the eye, in the ſame manner as the hairy filaments lie under the leaves of an artichoke on its disk or receptacle. I have above deſcribed the colour of theſe fibres; I ſhall only obſerve further, that this paint, with which their larger extremities are tinged, is likewiſe diffuſed deeper downward: and the other parts of theſe inward fibres are, as I have ſaid before, tinged with a red or purpliſh colour. Thoſe fibres which ſtand in the middle of the eye are ſtraight *h h*; but thoſe that are on the ſides appear ſomewhat oblique, and the reſt run a little crooked alſo; but all terminate in a ſubjacent membrane, with which they are naturally united, but from which they are eaſily broken off when handled. This membrane, therefore, very finely exhibits almoſt the ſame diviſions in dotted figures, which the omnipotent Creator hath been plaſed to make on the cornea *c b b*, with ſuch ſtupendous and inimitable art. Concerning theſe fibres we are further to obſerve, that if the cornea be ſeparated from, without hurting or breaking them, they very beautifully repreſent the hexangular diviſions of the combs: but when the cornea is pulled off in ſuch a manner as that ſome particles of theſe fibres adhere to it, then their figure is not ſo diſtinguiſhable. Theſe fibres are very eaſily broken, when the cornea is ſeparating from them; for they are connected with the cornea, and are received into its cavities: but this union is rendered ſtronger by means of innumerable pulmonary tubes, which aſcend near thoſe fibres towards the cornea, and, as I think, conſtitute its hexagonal diviſions: nay, they likewiſe probably contribute to expand the eyes at the time when they are caſting their ſkin, and are very ſoft and tender, by force of the air impelled within. Hence near the diviſions of the eyes, the pulmonary tubes will have the ſame uſe and ſituation as I have before attributed to the ſame tubes, in regard to the wings of Bees. I would not, however, have my opinion in this caſe conſidered farther than as a probable conjecture. One of theſe fibres is likewiſe united with another immediately under the cornea; and a little lower ſome cluſterings and knots are obſerved among theſe fibres. But where theſe fibres are broken off, when the cornea is not regularly taken from them, their full purple colour, as hath been ſaid above, is found not to terminate there, but deſcends deeper. It is indeed very wonderful, in what manner and in what numbers theſe pulmonary tubes aſcend near theſe fibres, and are united together. I muſt own that I ſhould be very glad to examine, of what nature theſe fibres are, whether muſcular or nervous; as alſo whether or not they have any motion, and of what kind of particles they are compoſed: but it has been abſolutely impoſſible for me to examine all theſe things, for both my ſight and inſtruments failed me. However, I have again ſeen the Creator conſpicuous with human eyes in this ſtupendous conſtitution of the moſt admirable and unſearchable little parts, which exhibit, as it were engraved thereon, the real image of his inexhauſtible power and wiſdom.

That I may proceed in the order wherein I began, I ſhall now deſcribe that part, Tab. XX. fig. v. *x*, towards which all the fibres hitherto mentioned converge, as towards a common center, and to which they are united, as the threads of velvet with their web; this part is white and fibrous, and is ſituated within the eye: but the pulmonary tubes before deſcribed aſcend through and on each ſide of it towards the fibres. The figure of this membrane is exactly like the external figure of the eye, one ſide of it being lunar or like a creſcent, and the other ſemicircular. It is white in the middle, but in the border it partakes ſomewhat of the colour of the ſuperior or upper part of the fibres, the impreſſions of which are ſeen thereon.

This membrane, being removed from its place by the help of a fine inſtrument, there appears cloſe under it another membrane, much more delicate and tender, as alſo clearer: and this, by means of pulmonary tubes, is connected, though not very ſtrongly, with the former.

There is placed under or behind this membrane, but a little lower or deeper in the eye, another or ſecond ſpecies of fibres, fig. IV. *n n n*, and fig. v. *q q*, which being tranſverſely applied to the lower ſurface of the membranes, are like ſo many beams or tranſoms, which ſupport the pyramidal fibres laid over them. Theſe alſo differ from the former pyramidal fibres, both becauſe they are fewer in number, and by far leſs delicate; though notwithſtanding their thickneſs I could not eaſily divide them. Some of theſe fibres are laid over others, Tab. XX. fig. IV. *o*, in the ſame manner as they are wont here at Amſterdam to pack beams or pieces of timber on board of ſhips to be exported; that is, they were here and and there ſeparated from each other, and ſpaces were left between them; and by this means was exhibited an object, like the courſe of the muſcular fibres in the papillæ of the kidneys. Theſe things appear more beautifully when the diſſection of the eye is begun in the lower part, as may be ſeen fig. V. under the letters *q q*, which repreſent the ſame fibres. Of what nature theſe fibres are, and whether they communicate with the brain *s s*, I have very anxiouſly inveſtigated, and, if I am not miſtaken, I have found that they are joined to the brain, nay, they are of the ſame colour with the brain, that is, ſomewhat grayiſh in part, and elſewhere freſh coloured: hence I call them the cortical fibres, becauſe they are like the cortical ſubſtance of the brain. In the Wray-fiſh, there is ſeen a very remarkable nerve, iſſuing out of the brain, and terminating in a large inflated extremity. This is conveyed towards the bone of the head, and is there admirably divided on each ſide into many filaments, to which thoſe fibres in the Bee's head likewiſe anſwer, and it may in ſome meaſure be likened; though theſe nerves in the Wray-fiſh do not all ſeem to contribute to the ſenſe of ſeeing, but rather to that of hearing or ſmelling: this matter therefore ſtill remains to be inquired into.

Between theſe fibres is ſeen the cortical ſubſtance of the brain, the nature of which theſe fibres do not ſeem to be unlike. It is manifeſt that this ſubſtance *s s*, as well as the matter of the fibres *q q*, remarkably communicate with the brain, indeed that they both riſe out of it.

The brain of Bees conſiſts of four pair of diſtinctly conſpicuous parts, to which, as a fifth may be added, namely, the ſpinal marrow within the ſkull, or the principle or origin of theſe little parts *r*; nor can I beſides theſe find any others in this inſect, not even the ſo famous pineal gland *. The two foremoſt of theſe little parts, fig. VI. *c*, are ſomewhat globular or pyriform, and emit two nerves on each ſide, which are divided again into two parts *d d*, but their courſe, or the way they are ſent off, is ſtill a ſecret to me. The other three pair of little parts I have not yet ſo plainly diſcovered, as the firſt here deſcribed, becauſe they communicate and are connected with the three particular little eyes before mentioned, which are placed in a triangular form, fig. I. between the larger eyes here explained, and divided in the manner juſt laid down, though I could not ſo diſtinctly as I could have wiſhed explain the method whereby this connexion and communication are performed. The firſt thing that I have obſerved diſtinctly with regard to theſe little eyes, is that they alſo have pellucid cornea; and ſecondly, that in their cavity there likewiſe appears a coloured little part, which may be called the uvea. But of what nature this ſubſtance, which is under the uvea, is, and whether it likewiſe conſiſts of numerous fibres, or is itſelf a ſingle fibre, I cannot determine, though it ſeems to me to be a continued ſubſtance. Thirdly, below this we ſee thoſe three pair of little parts, which are as it were encloſed within it: theſe are the reaſons why I call theſe parts eyes. To which may be added, that the eyes of Spiders and Scorpions are externally formed exactly in the ſame manner, and are ſmooth, glittering, and without diviſions, and they are diſperſed as thoſe that are diſpoſed at random over the body. The Wolf Spider, which catches its prey by leaping on it, and not by means of webs, has its eyes placed in the ſame manner. But this ſpecies has a very exquiſite and incredible ſharp ſight, compared with other Spiders, which ſeem almoſt blind and, as it were, deſtitute of motion, that they may catch their prey, if any falls into their ſnare, with greater certainty. I have not yet diſcovered the internal ſtructure of theſe three eyes of the Bee. The letter *b*, fig. VI. likewiſe ſhews the brain, or rather one pair of thoſe parts of the brain. We have before deſcribed and explained by what means the cortical ſubſtance of the brain, is ſhewn when the fibres are taken from it. The letters *e e* ſeverally ſhew the third and fourth pair of little parts, or the cerebellum, and alſo the manner wherein theſe parts communicate with each other. The cortical fibres, fig. IV. *n n* that iſſue from theſe, are repreſented in their ſituation in the fourth figure. In order to obſerve the principle or beginning of the ſpinal marrow, fig. V. *r*, it is neceſſary to begin the diſſection of the eye at the loweſt part, or where the head is joined to the thorax. But then if you only remove the horny head, you will immediately ſee the fat, and the originations of the pulmonary tubes, which are here very numerous, and the larger branches of which are diſtributed towards the upper parts; but the ſmaller are connected with the fat, in the ſame manner as the ſcapus or ſtalk of a bunch of grapes is with its berries, and hence is produced a moſt agreeable ſight: one or two membranes alſo muſt be there ſeparated from the brain, before the marrow comes in ſight. But then one may ſee there very beautifully that other ſpecies of the fibres of the eye, Tab. XX. fig. V. *q q*, which I have called the cortical fibres, and repreſented under the letters fig. IV. *n n n*, in the preceding figure of the eye, the diſſection of which was begun at the upper part: then, at the ſame time, may be very beautifully ſeen alſo the inferior or internal ſurface of the cortical ſubſtance of the brain, fig. v. *ſ ſ*, which partly covers theſe cortical fibres. This cortical ſubſtance likewiſe ſeems to be here divided in the middle, which diviſion is covered with a kind of thin membrane. This little part and its diviſions I have marked with the letters *a a* in the ſixth figure, which exhibits the ſection in the upper part. The marrow, fig. v. *r*, as hath been obſerved, appears then very beautifully placed between the cortical ſubſtance of the brain; and at the ſame time it may be ſeen how it partly communicates and is connected with that cortical ſubſtance. But I ſhall afterwards particularly delineate, to the glory of the great Creator, and deſcribe the whole marrow with all its nerves. I ſhall only obſerve here, that the letter *y*, fig. I. and v. exhibits the firſt knot which the marrow forms out of the brain; but ſo, that in one figure it is placed above, in the other below. Fig. v. *z z*, are the pyramidal fibres of the eye, deprived only of their cornea on each ſide. *u u* Expreſs the thickeſt part of the fibres, and the place where they are moſt coloured. *x* Shews the internal coat of the eyes, before demonſtrated under the letter *i* fig. I. in which the pyramidal figures terminate.

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* The Bees have probably all that delicacy of ſmell, for which they are celebrated; but it is not true that they diſtinguiſh perfumes by their fondneſs, and ſtinks by their averſion: certain ſmells excite and others offend them; but their notions of ſweet and ſtink are not the ſame with ours. They are fond of places where urine ſtands to putrefy, than which there is ſcarce any ſmell more offenſive. It had been ſaid they would fly in fondneſs to a man who had a noſegay of ſweets about him, and that they would ſting any who carried ſtinks; but Mr. Reaumur made the experiment and found it falſe. There are wonders enough in the real hiſtory of theſe animals; 'tis wrong to diſgrace them with falſe and fictitious tales to make all ſuſpected.

Here alſo about the lower verge of the head ſome parts of the mouth are ſeen, together with the two horny prominent little parts, wherein the muſcles of the teeth or jaws are in part fixed, and alſo the muſcles belonging to the beginning of the œſophagus. But I paſs by all theſe things at preſent, nor ſhall I attempt to deſcribe the organs of hearing, or thoſe of ſmelling, as I have not been hitherto able to obſerve any veſtiges of ſuch; though I ſhould ſcarce believe, that the all-powerful Creator, who hath given to the Bees the organs of ſight ſo wonderfully formed, ſhould deny them organs for the other ſenſes. But ſo great is our weakneſs, that we are not able to comprehend and underſtand natural things.

It is likewiſe very difficult and hard to find the organs now mentioned in fiſhes and many other animals, becauſe they have no external paſſage or opening. Thus I have obſerved in the Chameleon, that the aperture of the organ of hearing opens into the mouth; which is likewiſe the caſe in the Frog. And hence it neceſſarily follows that the knowledge of the ſtructure of one animal throws a light on, and ſhews us the way to that of another. Indeed, comparative anatomy is a moſt faithful and liberal miſtreſs, ſince the parts that are obſcure and hard to be ſeen in one animal, may be ſometimes very diſtinctly traced in another. Before I diſmiſs the eyes, I ſhall firſt briefly ſubjoin here what I have ſeen and obſerved about thoſe of ſome other inſects.

The eyes we have been hitherto deſcribing are formed in like manner in the working Bee: there is however this difference that in the latter they are vaſtly ſmaller, and therefore have the fewer number of inward fibres. But to proceed in order, I ſhall here obſerve, that if the ſkull, together with the cornea of theſe three little eyes, be taken off the head at the ſame time, then immediately between theſe eyes, and under the antennæ or horns, are obſerved two oblong pulmonary bladders, which I have not ſeen in the head of the male, and which probably make the working Bee light, and give it a greater agility. There is a larger quantity of fat in the head of the working Bee than in that of the male. This fat being placed on a piece of very thin glaſs, and left ſo until it is dried, becomes entirely pellucid, becauſe its tender connecting white membranes grow dry by this means, and hence alſo the pulmonary tubes diſtributed through this fat now become conſpicuous. This fat adheres in a wonderful manner, linked as it were, and twiſted under the ſkull; the muſcular fibres of the jaws are alſo here more numerous than in the head of the male. But the brain, the tranſverſe cortical or gray fibres, and the cortical ſubſtance of the brain itſelf, are here conſtituted in like manner as in the head of the male Bee, but they are clearer and more eaſily examined; for the inverted pyramidal fibres ſituated above are fewer in the working Bee, and do not all prevent the ſubjacent parts being ſeen.

The eyes of the Waſp are conſtructed nearly in the ſame manner, and in their external and internal form reſemble the Turkiſh kidney-beans, being bent ſomewhat inwardly towards the ſides of the horns or antennæ, as if there was ſome part cut off there. The internal fibres anſwer to the external diviſions, as before obſerved; for as the pyramidal fibre is extended by every diviſion, it neceſſarily follows, that the internal figure of the eye is entirely like the external.

In many ſpecies of inſects there is a conſiderable and wonderful difference in reſpect to the external figure of the eye. How the eye of the Rhinoceros Beetle is diſpoſed and faſhioned, is ſhown by its figure.

In the Bee of Goedaert, which is really a dunghill Fly, the eye is framed nearly in the ſame manner as in the working Bee; for under the diviſions of its cornea, there are likewiſe placed a great number of pyramidal inverted fibres, which being broken off with the cornea, a very beautiful red or ſomewhat purpliſh matter preſents itſelf; but when the cornea is removed from the pyramidal fibres without hurting them, they appear yellowiſh. There are likewiſe innumerable pulmonary tubes in this eye, and a great quantity of fat.

In the Libella, or Fly of Dr. Hooke, called by the Engliſh the Dragon-Fly, and in Dutch Puyſtebyter and Rombout, the eye, in reſpect to its external diviſions and internal pyramidal fibres, differs conſiderably from the eye of the Bee; for the upper diviſions are much larger in it, than the lower, and the internal pyramidal inverted fibres, which anſwer to the upper diviſions, are in the ſame manner much larger than thoſe which are connected with the lower. The colour of the larger pyramidal fibres is purpliſh, but the ſmaller are duſky or blackiſh. It would indeed be worth while to ſpend ſome time in the examination of this eye, becauſe a very large aſſortment of theſe fibres is diſtinctly viſible in it, and may be conveniently enough managed; beſides that in the hexangular diviſions of theſe fibres, which are received into the cavities of the cornea, ſome myſteries ſeem to be ſtill hidden. I hope I ſhall be able to inveſtigate them at ſome other time, when I ſhall enter into a more exact examination of the many obſervations that I have hitherto propoſed; for the attentive ſpirit that is neceſſary in ſuch a number of things as are treated of therein, muſt at times relax and grow languid; and therefore I ſhall not deny but that I may probably be in ſome things deceived.

Some one may here object that the parts hitherto deſcribed are not eyes, but ſurely nothing is more plain and evident. The juſtly celebrated Hooke made ſeveral experiments to prove this: among others he wounded theſe eyes and cut off a part of them, by which means the creatures loſt their ſight entirely. This experiment may be made with little trouble; and whereas the wound and pain occaſion ſome change about the ſight, nothing more is neceſſary but to cover theſe eyes with a little black paint mixed with oil, with a pencil, by this means theſe inſects become blind, and by all their actions immediately ſhew a perfect defect of ſight. This experiment may be beſt made on thoſe Flies, the eyes whereof have no hairs, and therefore may be eaſily coloured. It is wonderful to ſee how tame and gentle the Fly becomes when its eyes are thus covered with paint; it ſuffers itſelf to be caught every moment, and when it runs or flies, you will ſee it ſtumbling everywhere, and when this happens it is driven back, like a ball, by whatever oppoſes it; unleſs it ſhould perhaps fix itſelf quick enough by the help of its claws, and thus avoid falling, as I have ſometimes obſerved.

This is the ſtructure of the Bee's eye, and of the eye of other inſects in general. The famous Dr. Hooke hath endeavoured to exhibit a magnified figure of ſuch an eye, deſigned from the Libella in the twenty-third and twenty-fourth plates of his juſtly celebrated micrography. It will be now asked by what means is the ſenſe of viſion performed in Bees and other inſects? I anſwer, that the conſtruction of the eye ſhews clearer than the light at noon, that viſion is not performed in it, as it is in us, and many other animals, by collecting the rays of light, which paſſing through the pupil fall upon the retina; but merely by the contact of theſe inverted pyramidal fibres, formed by the light propelled through the cornea. Theſe eyes are ſo diſpoſed as to receive the appearances of things by the ſimple appulſe of the reflected light: and this method of ſenſation cannot but be very lively. But as the pupil is never in theſe creatures contracted as it is in us, nor hath any foramen or aperture, hence it follows that the ſenſe of ſeeing muſt be very perfect in inſects, on account of the great number of rays which conſtantly fall on their eyes. And hence it likewiſe is, that many inſects ſee in the night: the Dragon-Fly, therefore, from the ſame cauſe, very quickly catches its prey flying. The organs of ſight, which inſects poſſeſs, can by no means be compared with our eyes, or with the camera obſcura, formed upon their principle, in which the appearances of things are by the help of reflexion painted on a paper or white cloth. On this occaſion I cannot but inſert an incident, which the illuſtrious and incomparable Boyle, in his treatiſe of colours, relates of a blind perſon, who, by diſtinguiſhing the roughneſs of coloured ſubſtances, could accurately diſtinguiſh their ſeveral colours by his fingers. This method of ſeeing, if it may be ſo called, being performed by touching, is in ſome meaſure like that which obtains in the eyes of inſects. But how this viſion is really performed in inſects, and by what means that great number of pyramidal fibres are excited by the light falling on them, as alſo how this motion is communicated to the ſubjacent reticulated membranes, and from them afterwards is conveyed to the tranſverſe fibres underneath; and from theſe again to the cortical ſubſtance of the brain; from the latter to the nerves and at length to the origination of the marrow or brain, no perſon can explain: this can be known only to the all-ſeeing Creator of the univerſe. He alone can tell whether viſible appearances or objects in inſects are ſtopt on the uvea or not. It is enough for me to confeſs my own weakneſs, and, after explaining the conſtruction of this eye, to proclaim aloud the praiſes of the ſupreme Architect, I muſt likewiſe acknowledge that I began theſe obſervations with the greateſt pleaſure at the end of September in this year 1673, and that they gave me more delight than if I had ſeveral hundreds years added to my life. I hope that this matter will ſhew the omnipotence and unlimited power of God, and inflame with the moſt ardent love towards their Creator, thoſe frozen ſouls, which ſtill deny the divine providence in reſpect to theſe little creatures. Indeed if we could accompliſh this with our labours, it ought to give us the greateſt joy, for it is for this purpoſe only and not to trifle away time, or acquire immortal fame or glory, that we ought diligently to inveſtigate the works of God.

I likewiſe ſaw at the ſame time, that each of the antennæ or horns, where they are articulated with the head, have three or four diſtinct muſcles, by the help of which they can be moved various ways, and may therefore both aſſiſt the ſight and defend the eyes from injury and any thing ſtriking againſt them. I have not attempted to diſcover the muſcles of the other joints, whereof the antennæ or horns conſiſt;

for they are ſo minute that neither the eyes, the hands, nor the underſtanding of man, nor our inſtruments we uſe can examine them juſtly. The ſame muſt be acknowledged of the muſcular fibres of the jaws or teeth, ſince we are incapable of diſcovering their excellent conſtruction and beauty, or of juſtly deſcribing or delineating them. I ſhall, however, ſay ſomething of the feather-like hairs of the head of the Bee, when I treat of thoſe of the thorax; which I ſhall now proceed to deſcribe.

The external figure of the thorax is in the upper part convex, but towards the hinder parts it is ſinuated, and is adorned with a ſomewhat prominent margin about its extremity. On each ſide of the anterior part there appear the ſcapulæ or ſhoulder-blades, by which the wings are joined: a little lower on each ſide under the wings and ſcapulæ are ſeen the points of reſpiration; whereof the orifices are oval, and ſurrounded with a horny margin. The under face of the breaſt is divided into two parts, which are ſtretched ſomewhat obliquely and bent downwards, and give inſertion to the laſt pair of legs joined to the lower edge, as the firſt pair of legs are articulated with the fore parts of the breaſt: theſe, when the head is drawn from the trunk of the body, adhere to the head, and are pulled off with it. The breaſt is of a horny or bony ſubſtance, and is thick ſet above, below, and on the ſides with feather-like hairs, which are of equal ſize and length in the upper region of the breaſt. Theſe hairs, which are diſtributed over the whole ſurface of the body, and are found even in the head of the common or working Bee, as alſo between and under the horns of the males, are all of them, as hath been ſaid before, perfectly like downy feathers, and particularly like the down of Swans, or thoſe remarkable hairy feathers conſpicuous in the tails of Peacocks; the middle ſtalk of which feathers is ſurrounded with many ſcattered lateral hairs.

Before I proceed to the diſſection of the internal parts, I muſt repeat again that Bees produce their humming noiſe with their wings only: ſince the ſmall, membranous, moveable wings at the ſhoulders, may eaſily produce ſuch a noiſe, by means of the air propelled from the ſubjacent pulmonary tubes: for no points of reſpiration open into the mouth, which is to be well obſerved: to this may be added, that the narrowneſs of the trunk is not adapted for modulating the air; if any of the latter ſhould be impelled thither out of the ſtomach, in which indeed I have found air. The wings of Flies are wonderfully formed in that part where they make this noiſe; though this ſtructure is very different in the various kinds, Some Locuſts indeed make a noiſe by the ruſhing together of the wings; and for this purpoſe nature has given them near the hinder part of the wing towards the breaſt a ſingular ſmall part, which, when moved, forms a diſtinct ſound like a thin plate of metal. Other ſpecies of Locuſts make a noiſe by rubbing their wings againſt their legs. Crickets and Mole-Crickets modulate the air in ſuch a manner by the help of their wings, that the chirping noiſe they make is produced from thence. The Graſshopper has two peculiar ſmall drums, like the drum of our ear, which, being ſtruck by the help of two lunated cartilages, vibrate the air in ſuch a manner as to produce that ſound. Beetles make a noiſe by rubbing the horny parts of their head againſt the articulations of the breaſt, and the parts about the tail with the caſes of their wings. All the inſects to which nature gave ſingular organs for making a noiſe are of the male ſex: this may be ſeen diſtinctly in the Locuſts, Graſshoppers, and others, the females of which make no noiſe. In regard to the wings of Bees, we may obſerve they are here and there briſtly, and that the veins and nerves conſpicuous in them, are only ſcattered pulmonary tubes, by the help of which, as we have before expreſſed in words and figures, the wings are for the moſt part diſpanded.

The contents of the thorax are various: they are the moving fibres of the legs and wings, and alſo ſome which are deſigned for moving the abdomen, and others for moving the neck. Theſe muſcular fibres fill almoſt the whole thorax. The other parts to be found there are the pulmonary tubes, ſome fat, the gullet, and the ſpinal marrow: all theſe I ſhall now paſs by, and only ſay ſomething of the muſcular fibres, and ſhall then proceed to the contents of the belly. On this occaſion I ſhall give a deſcription of the ſpinal marrow. The muſcular fibres of the breaſt, as we have already related, fill its whole cavity, and may be divided eaſily into thoſe which move the fore, middle, and the hinder legs, and into thoſe which ſerve to move the wings: for where theſe parts are ſituated, there are ſeen the tendons of thoſe fibres, which are afterwards expanded and fleſhy in the thorax, and afterwards becoming tendinous, above in the upper region of the breaſt, are there fixed as it were into an horny little part. The fibres which are implanted in the middle of the thorax ſtand almoſt perpendicular, but thoſe which are inſerted ſomewhat lower towards the ſides, are more oblique; and thoſe that are in the anterior part united to the legs, run entirely oblique and are almoſt flat. Where the muſcles are fixed to the wings, there is a kind of diſtinct articulation, beſides that by the help of which the greateſt motion of the wings is performed. If the fibres of the thorax are ſeparated from each other, they divide into oblong hairs, as it were, which are connected with delicate, white, nervous, and tranſverſe fibrillæ, and are at length here divided ſo minutely, that I muſt deſiſt from further ſearch; being filled, as before, with admiration of the divine Architect, who here in a ſmall fibre manifeſts to me his omnipotence and my weakneſs. For to this purpoſe only, and that we may terminate our greateſt deſires and ſtrength in him and in his pleaſure, all his works are offered to our contemplation. When I opened the margin or verge beforementioned, and which is viſible in the hinder extremity of the thorax, it appears full only of pulmonary tubes and fat.

The parts contained in the abdomen of the male are indeed as admirable as thoſe which I have before explained as ſituated in that part of the working Bee and of the female. But as no difference occurs here in regard to the ſtomach, inteſtines, and other parts, I ſhall deſcribe only the organs of generation in the male: for thus the difference between this male and the female, which has an ovary, and alſo between that and the working Bee, which is not furniſhed with either male or female organs, will be more evident. After this a ſhort deſcription of the ſpinal marrow ſhall conclude the whole of this diſſection. Though this ſpinal marrow be formed alike in each of the three kinds of Bees, yet I chuſe rather to deſcribe it particularly in the male than in the working Bee, becauſe the male has a larger body.

The genital organs of the male are extremely large and very eaſily viſible; for they poſſeſs the whole abdomen, nay, the abdomen of the males ſeem to be larger than that of other Bees, that it may be capable of containing them. This will be teſtified by the moſt ſerene duke of Tuſcany, Coſmus III. who in the year 1668, in company with the illuſtrious Mr. Thevenot, vouchſafed to view at my houſe, with great admiration at the ſupreme Creator, theſe parts in the Bee, and graciouſly to honour my labours by this unmerited viſit. The genitals of the male Bee, if we conſider the ſmallneſs of the whole inſect, by far ſurpaſs, with reſpect to the quantity of ſperm, thoſe of all other animals whatſoever. That ſeed is contained chiefly in the ſeminal veſicles or bladders, as is the caſe in other inſects, and in larger animals, as Moles, Hedge-hogs, and Rats, which, as they are ſwelled with abundance of ſperm, have greater plenty of it collected in theſe bladders than in their teſticles. I could almoſt ſay that it is ſo in man likewiſe; for when I compare the narrowneſs of the filament or veſſel of the teſticle with the capacity of the ſeminal bladders, and at the ſame time conſider the quantity of the ſeminal matter, generated in the veſicles themſelves, that it is not transferred thither, according to the common opinion, out of the teſticles. But to proceed; we muſt accurately obſerve, that the parts which contribute to generation, and alſo to exclude or expel the ſperm are the following: two teſticles, Tab. XXI. fig. I. *a a*; two vaſa deferentia *b b*; theſe are diſtended *c c* on each ſide to a larger and more remarkable ſize than the teſticles themſelves: the two ſeminal bladders or veſicles *d d*, of a ſtupendous bulk; the root of the penis *e e*; a very conſiderable horny little part which is placed *f* ſomewhat towards the anterior end in the thickeſt part of the root of the penis; the penis itſelf, or the part analogous to it or like it *g*; another little part of a bright red colour diſtinguiſhed *h* by five diviſions; and under it, on the other ſide, another but larger pyramidal little part *i*: laſtly, there are the two pointed *k k* yellow appendages of the pudendum, with red ends, and inveſted with a very thin ſkin, which contain this ruddy colour, and when wounded readily diſcharges it. The little figure marked fig. II. *o* repreſents all the parts hitherto recited in their natural ſize. The teſticles, fig. I. *a a* are placed in the upper region of the abdomen, and ſituated as it were at the back or loins; as is the caſe in Birds, Frogs, and other animals. They ſeem to me to conſiſt of tubes, as in the water Beetle, the genitals of which I ſhall hereafter delineate. Innumerable pulmonary tubes are likewiſe inſerted into the teſticles, which greatly prevent the ſtructure of the latter from being inveſtigated according to one's wiſhes. Theſe are of a pale citron colour with a tinge of purple, which is likewiſe the caſe in Silkworms. The vaſa deferentia *b b* are very ſmall, ſlender, and delicate in their ſtructure, and appear whitiſh on account of the ſperm which ſhews itſelf through them: they are twiſted like the tendrils of a vine; nor do they appear to the obſerver until after the pulmonary tubes, which join together their knots and convolutions, are gently and by degrees cut off with great care and very tedious labour. Theſe pipes are ſo ſtrongly connected with the winding of the vaſa deferentia, and with that part of them which becomes broader, and alſo with the teſticles themſelves, that they ſeem to conſtitute as it were one body with all theſe parts. The vaſa deferentia are here, as they are in man and brute animals, joined by one extremity to the teſticles: a little further examination ſhews very plain, how theſe vaſa deferentia are dilated, and reſemble as well in reſpect to their colour as the inſerted pulmonary tubes, ſecondary, or other teſticles. But being more accurately examined, they diſcover within a conſiderable cavity, which the teſticles have not. They are likewiſe of a glandular ſtructure, and are diſtended with a ſeminal matter, which immediately flows out of them when wounded. Before theſe veſſels are connected with the root of the penis and open into its cavity, they are a ſecond time contracted in a remarkable manner, and appear only ſimple tubes, or ſmall ſeminal veſſels: they are at length inſerted by their other extreme into the lower part of the ſpermatic bladders. I think that in this dilatation *c c* of theſe veſſels, a ſeminal matter is certainly ſecreted; and in like manner I do not doubt but the ſame happens in man, where the vaſa deferentia are dilated into the form of bladders.

Next the vaſa deferentia are placed the ſeminal veſicles *d d*; theſe are wonderfully large, and are full of ſeminal matter; they are whiter than ſnow, and are of a very fine texture. They ſeem, indeed, to be of a glandular conſtruction, only that the muſcular fibres alſo, by the help of which they are contracted to caſt out the ſperm, run through them; ſuch a contraction is common to all the other muſcular fibres, after they are drawn out of the body: I have ſeen even theſe veſicles, after being taken out of the body of the Bee, contract and wrinkle themſelves up by degrees. Here we ſhould well obſerve, that near the beginning of the root of the penis two remarkable nerves *n n* are inſerted in the ſpermatic veſſels, and which give many branches both to theſe veſſels and to the root of the penis, contributing to the motion and titillation of theſe parts. That part of the ſpinal marrow *m*, from which theſe nerves ariſe, is here delineated ſomewhat laterally. Near theſe nerves likewiſe, there appear two other little parts or ligaments *l l*, by the intervention of which the genital parts are tied or faſtened in their places in the abdomen, ſo that they cannot go out of their proper ſituation without force: this, however, I would not have underſtood of the root of the penis, and ſome other parts which are moveable, as ſhall be ſhewn hereafter.

Near the orifices of the ſeminal bladders and vaſa deferentia, when the latter are more contracted, the root of the penis ſhows itſelf, Tab. XXI. fig. 1. *e e*; it is a conſiderable long and crooked tube; it becomes the more dilated and diſtended, the more it advances toward the outſide, until at length it expands itſelf into a globe of conſiderable thickneſs, and being then ſomewhat contracted again, it forms at laſt a more conſiderable oval tubercle or ſwelling. On the inſide in this dilatation of the root of the penis, there adheres a pelucid horny part, of a deep brown, but ſomewhat ruddy colour, and ſet with ſmall cavities *f*. This part appears to be divided in the middle, and in that place is ſeen the limpid and clear colour of the penis. In the anterior or fore ſide, but a little on one ſide of the part juſt now mentioned, may be obſerved two other horny, ſhorter, and ſmaller parts, which ſeemed to be joined together. The ſtructure of the root of the penis is nervous or cartilaginous, not yet hardened. Where this root is diſtended with ſperm, it is much whiter than where its ſubſtance is more plainly ſeen, being in ſuch parts limpid, and not ſo white, but rather reſembling glaſs. This is the caſe likewiſe in the ſeminal bladders; where theſe, not yet ſwollen with the ſeminal matter, preſent their proper ſubſtance to view.

Under the little part juſt now deſcribed, and ſomewhat on one ſide of it, appears the penis *g*, or the part that ſeems moſt analogous to a penis; of this I ſhall ſpeak more largely hereafter. On the other ſide is ſeen *h* that the genital veſſels, which appear to be diſtinguiſhed into five diviſions, and a little lower, and as it were on the other ſide, there is ſeen another ſimilar but undivided little part *i*, which when diſſected is found to be ſhaggy, unequal, and as it were briſtly. The former little part which is divided by five rings, appears alſo to be of the ſame ſtructure. Theſe three hinder little parts, as well as the ſubjacent and hollow appendages *k k*, appear wrinkled and contracted, like compreſſed, tender, and delicate membranes; the reaſon of which will be ſoon ſhewn. The ſeminal veſicles therefore, as has been obſerved, and the vaſa deferentia, as well in their beginning near the teſticles, as where they terminate after they have grown narrower, as alſo the root of the penis, every part of theſe is pellucid: wherefore, whenever they are diſcharged of ſeed, they appear like white glaſs, or like veal, or any other jelly: but when the ſperm is ſeparated in the veſicles or root of the penis, there is then a very fine appearance, as of glaſſy marble or agat, diſtinguiſhed or variegated with white ſpots. This is a ſhort deſcription of what belongs to the ſtructure of theſe parts: many things more may be obſerved, which I ſhall defer to another opportunity. If we conſider the uſe of theſe parts in coition, and the manner the ſperm is ſecreted, theſe are indeed ſo admirable that they almoſt ſurpaſs all that has been hitherto ſaid. For the little part which we have called the penis *g*, as alſo the other part with its five rings *h*, and the cloſed and pointed appendages *k k*, are all of them erected, and in the erection turn and invert themſelves in ſuch a manner, that their internal ſurface is turned perfectly out: this is done in the ſame manner as we take off our glove, or pull the ſkin off a Hare or other ſuch animal, by turning the inſide out. Hence I am in doubt whether this ſhould be called an erection, rather than an inverſion, produced by the heat of the parts; all theſe parts are at the ſame time alſo diſtended with air. Indeed I do not remember to have hitherto ſeen any thing in nature wherewith I can compare this action. I am ſenſible that Snails turn out their horns, and take them in nearly in the ſame manner; but the air contributes nothing to this, the whole action is evidently performed by the help of conſpicuous and elegantly conſtructed muſcles; but this does not happen in regard to the erection in the Bee. If many Bees are kept together in a box, it frequently happens that theſe parts are obſerved to turn themſelves out of their body in the manner juſt mentioned: and on this occaſion I have alſo found that the ſame thing may be effected by art; that is, by taking the body between the fingers, and then expreſſing or ſqueezing theſe parts out at the hinder part.

When the male is about to diſcharge the ſperm, or to erect or rather evolve the penis, then, that I may now ſpeak in general of the extuberance of the genitals, the cloſed and pointed appendages are turned out. This is performed in theſe as well as the reſt of the parts, by the air which is impelled inwards, for at that time they are all inflated with wind. The inverſion of theſe parts is performed in this manner; the extreme and hairy part, Tab. XXI. fig. III. *r*. of the pudendum is firſt forced out by the Bee, and then the horny *q q* extremity of the ſame pudendum is likewiſe advanced out from the laſt rings of the body, and at the ſame time the root of the penis *e e*, together with the ſaid horny part *f* contained in it, ſtarts or is thrown forward, and the vaſa deferentia *c c*, and ſeminal veſicles *d d*, are likewiſe drawn ſomewhat towards the fore parts. Afterwards the four diſtinct little parts begin to ſwell and throw themſelves out of the body; that is, the two pointed appendages *k k*, the pyramidal particles *i*, and the fine ringed little part *h*. Before theſe four parts are erected and thruſt forth, one may ſee in what manner they ſwell forwards through four diſtinct little cavities, ſuch as are ſeen in the fingers of a glove, when you have juſt begun to invert them. And further, one of the cloſed appendages, as alſo, the little part with its fine rings are ſeen through the skin.

The appendages, as I have already obſerved, are firſt inverted, and their baſis is then turned out, Tab. XXI. fig. IV. *l l*, when we ſee their cloſed extremities ſtill lying between them and not yet inverted. But the pyramidal little part alſo *i* is then unfolded more and more upwards, as well as the fine ringed little organ *h*; the horny part alſo ſituated at the root of the penis *f* is then propelled or puſhed further forwards, and is fixed higher in the horny little part of the pudendum *q q*; but the hairy part of this is no way changed in its ſituation.

Then the appendages being by degrees entirely inverted, appear diſtended and ſwollen, Tab. XXII. fig. I. *k k*, at which time the root of the penis *e*, together with its interior little horny part *f*, are moved yet farther outwards, and this begins to penetrate ſomewhat deeper into the cavity *g g* of the horny or bony part of the pudendum: the pyramidal little part *i* alſo is now turned further out, and the little part with fine rings *h*, which is then partly inverted now appears to the eye: however, the ſhaggy part *r* of the pudendum as yet ſuffers no change.

But at this very time the pyramidal little part fig. II. *i* is at length all turned out and expanded, and the other little part likewiſe ſhews itſelf: it has five diviſions, and ſhort briſtly hairs; and it now appears very elegantly and beautifully bent *hh*. This makes the more agreeable ſight, as theſe five diviſions are of a bright red colour, but the reſt of this little part is membranaceous and whitiſh. The cloſed appendages *k k* retain their figure, and only the horny little part ſituated in the root of the penis, is by degrees more and more thruſt out, and is further introduced into the horny part of the genitals. Hence it happens that the root of the penis *e* becomes ſtraighter, whilſt the ſhaggy part *r* of the pudendum ſtill remains as it was.

If one continues to preſs out theſe parts further, the skin being the pyramidal little part, and that which has five diviſions, is by degrees widened and diſtended; and hence it afterwards happens, that what is called the penis, fig. III. *g*, appears there in this manner; it turns itſelf entirely out, exhibiting a membranaceous ſtructure, and beautiful corrugations in the head *t*. Then the pyramidal particle *i* likewiſe becomes entirely unfolded and expanded; and the horny little part *f* encloſed in the root of the penis, is entirely, with a great part of the root itſelf, preſſed out of the body. This is forced through the middle of the horny, Tab. XXII. fig. III. *q q*, and hairy *r r* part of the genitals: hence the little part with fine rings is then likewiſe dilated and extended ſo far, that on each ſide it appears wholly reclined towards the hairy part *r r* of the pudendum. As theſe parts are pellucid, the horny little part *f* is ſeen through the skin of the penis, whilſt in the mean time the little part with fine rings being plainly drawn down under it, reſembles as it were an expanded membrane, and appears marked with ſome lines or bright red grooves or furrows, between which are ſeen its five diviſions. I do not think it neceſſary to delineate all and each of theſe: but the cloſed appendages *k k* are then, without any regard to theſe ſeveral changes, obſerved to remain in their former figure and ſituation.

Whilſt theſe parts are in this ſtate below the penis as it is called *g*, is ſeen a conſiderable aperture *u*, which appears underneath and between the diviſions of the horny little part ſituated inwardly at the root of the penis; through this aperture, not only the ſaid little organ but a great part of the root of the penis may be forced, and thus will cauſe the ſperm to flow plentifully from thence. The before deſcribed cavity of the genitals ſeems from hence, therefore, to be the true paſſage *u* of the ſperm, though for ſome time I have attributed that office to what is called the penis *g t*; but I obſerve that this as well as the other parts is cloſed and has no orifice. Wherefore I cannot imagine what uſe this little part is of; as I do not yet conceive the purpoſe of that other little part, which one may take for a penis. On the contrary, I think I very clearly ſee that the internal horny particle *f* is made in order to dilate the root of the penis with its ſtiffneſs, and to preſerve it when opened, by which an eaſy paſſage is given to the ſemen through the latter. Indeed, in my opinion there was a neceſſity for ſuch a caution, on account of the great impetus wherewith theſe parts are forced out; for if that little part were not hard as horn, the ſaid paſſage would be eaſily ſqueezed together, and conſequently the ejection of the ſeed hindered. But whether theſe particles which are inflated with air, contribute to propel the reſt of the parts out of the body, and whether the cavity through which I ſuppoſe the ſperm paſſes, are natural or produced by the force wherewith I preſſed theſe parts out of the body, muſt be ſtill more accurately inveſtigated, for theſe are not ſufficiently clear to me.

It is now time to deſcribe the peculiar inverſion of theſe parts. The cloſed and pointed appendages, Tab. XXI. fig. I. *k k*, then begin firſt to emerge and to be inverted by degrees, fig. III. and IV. *k k*, until at length they are all entirely thrown out, Tab. XXII. fig. I. *kk*. At the ſame time the pyramidal particle prepares to iſſue, Tab. XXI. fig. III. and IV. *i*, and turning itſelf more and more about it, Tab. XXII. fig. I. becomes extuberant, until finally it is entirely extended, fig. II. *i*. Then the five ringed little part, Tab. XXI. fig. I. *h*, is obſerved, fig. III. and IV. *h*, to appear by little and little, and to invert itſelf, Tab. XXII. fig. I. *h*, until it is diſplayed a little more, and then it is entirely inverted, exhibiting to the eye a very beautiful ſight, fig. II. *h h*. In the laſt place, Tab. XXI. fig. I. *g*, the penis, as it is called, is by degrees propelled between the pyramidal part and that which has five diviſions, and is inflated with air, Tab. XXII. fig. III. *g*, *t*, and at the ſame time the quinquepartite little part is entirely dilated, and under what is called the penis, entirely towards the hairy part of the genitals *r r*. In the mean time whilſt theſe things are doing, the root of the penis *e* and its inward horny particle *f*, is by degrees moved forward and thruſt out of the body, ſo that the orifice out of which the ſperm is diſcharged *u* may be very diſtinctly ſeen.

As almoſt all theſe parts are thruſt out by force of the air, the reaſon is obvious why ſome of them, when not diſtended with air, appear wrinkled and contracted in the body, Tab. XXI. fig. I. *g h i k k*. It appears alſo for what reaſon I call this little part *g* the penis, and that is, becauſe it bears ſome reſemblance to a penis, Tab. XXII. fig. III. *g t*. Indeed, if it be perforated and erected by force of blood and ſperm, one may more properly take it for a penis than the fine ringed little part, which is likewiſe impervious. The poſterior part of this penis next to the body *u* is very beautiful, reſembling in brightneſs the foot of a cryſtal drinking glaſs with ſmall ribs, only that a little whiteneſs intermixed obſcures in ſome meaſure the brightneſs.

From the deſcription and figures of the genital organs thus exhibited, it is ſufficiently evident, that it is ſcarce poſſible that all, and indeed, hardly credible that any of theſe parts ſhould be admitted into the body of the female: wherefore, I firmly believe that the female Bee is impregnated only by the ſtrong effluvia of the male ſperm, after the Bee has diſcharged it: nor would I have this doctrine rejected by any perſon as abſurd though ſeemingly ſtrange. For firſt, though a penis or little part like it ſeems to be given to the male Bee, yet this is by no means ſufficient for impregnation; becauſe it is not only impervious, but by reaſon of its ſituation and figure, it cannot, I think, be admitted into the female's body. Nay, though the penis ſhould be admitted thither, yet it could not convey the ſperm into the uterus, the latter being diſcharged through a quite different paſſage. In Hornets there is a wonderful and diſtinctly viſible penis; on each ſide of it are ſeen two horny hooks like claws, by the help of which the male Hornet fixes himſelf to the extreme ring where the female's vulva is, and then advances its penis further into the uterus. In the Silkworms and in the horned Beetles the ſame may be ſeen ſtill plainer. I have found from experience that the male ſperm of Bees exhales a rank and ſtrong odour; ſo that if there be ſeven or eight males together encloſed in the little box, this is more ſtrongly infected with the effluvia of ſperm than any one could believe, who hath never ſmelled theſe ſeminal vapours. And though the parts alſo containing this ſperm have no aperture in the male, and the ſaid orifice was perhaps produced by me only, by the violent ſqueezing of the poſterior part of the body, yet it does not therefore ſeem leſs probable that the ſubtile particles of the ſperm may eaſily penetrate through the tender and inflated membranes of the genital organs, and by their effluvia only impregnate the female. Does not experience teach, that even the white as well as the yoke inſenſibly inſpire through the membranes and hard ſhell of the egg? Secondly, though the males were provided with a penis fit for real coition, yet they never have an opportunity of copulating with the female, ſince ſhe is always ſurrounded with great numbers of the working Bees, nor is ſhe ever any where left alone by them; ſo that one cannot by any means imagine that the working Bees grant the female a place and acceſs to exerciſe venery. But if any one objects, that the males probably engender with the female when they adhere about the cell, out of which the female iſſues; this cannot be allowed, ſince their genital organs are not obſerved to be conſtituted in ſuch a manner as to be accommodated to or for this buſineſs. However, if the aperture beforementioned, through which the ſperm flows, be naturally in the genital parts, I readily accede to the opinion of one of my friends, who thinks that the males when they penetrate through the noiſy ſwarm of the other Bees, rub a little of the ſperm upon the female's body, and thus impregnate her: but this opinion is deſtroyed if that orifice whence the ſemen iſſued is not natural. Upon the whole, it ſeems to me more probable, that the female is impregnated only by the ſtrong and very ſubtile effluvia of the male ſeed. For if only eight male Bees are able to emit a very ſtrong odour, what will four hundred of them together do in a hive? It is probable there is in general a greater number than this of males in one hive, which would not indeed be difficult to know, if one would count either the males themſelves, or the cells whence they are excluded. To which may be added, that other creatures impregnate their females only by contact, or by aſperſion or ſprinkling, as is plainly the caſe in Fiſh. In the fiſh kind we ſee plainly, that the eggs or ſpawn caſt by the female into the water, are only ſprinkled or daſhed with the melt or ſperm of the male, and are by this means fecundated. The ſame thing holds with reſpect to the Ephemerus, whoſe female flying in the air drops her eggs into the water, and the male then ſeeks after them, and ſprinkles and fertilizes them with his ſperm. As therefore the water ſerves Fiſhes as a medium, through which the impregnating virtue of the ſperm is communicated to the eggs, ſhall it be thought improbable, that the air is a medium of the ſame kind to the Bees, by means of which the ſubtile particles of the ſeed diſperſed through the hive, are transferred to impregnate the ovary of the female? Indeed the whole conſtitution of the genital organs of the male confirms this opinion. The ſame is likewiſe intimated by thoſe very ſtrong ſeminal vapours, which are perceived by the noſe, when even but a few males, at the time of ſwarming, lie encloſed for ſome hours in a box. To the reaſons hitherto advanced may be added, the golden or incomparable obſervations of Harvey, by which it is indeed evidently demonſtrated, that even in man and in brutes the ſperm never comes to the uterus, but that the more ſubtile and ſcarce perceptible particles of it change the whole body at the time of coition, and according to what I obſerved in the human ſpecies, impart or give a more perfect animation and motion to the eggs, while they are ſtill in the ovary. That the ſemen never comes into the uterus, appears moſt certain from the following experiment: let the penis of a Dog in the act of coition, be tied behind the knot which it then forms, and immediately cut off, and let the female be inſtantly opened, all the ſperm will be found ſticking in the vagina. In domeſtick fowls the Cock only emits his ſperm through two ſmall apertures, and rubs it to the vulva of the Hen; for he has no penis nor any remarkable production of the vaſa deferentia: in other inſtances theſe unite in one common channel, or, as in us, are produced out of the body by the help of the urethra: but in the mean time the ſubtile particles of this gallinaceous ſperm thus rubbed on the body penetrate through the membranes, nerves, veſſels, nay, through the whole body of the Hen, though they be intended to affect and impregnate only her ovary. In the ſame manner nearly the ſeeds committed to the earth, or being only on its ſurface, we ſee are affected by the earth's moiſture; ſo likewiſe a little barm, or yeaſt, ferments, moves and prepares the whole maſs. The little part which appears like a penis in the Bee, is wonderfully ſmall and delicate, and of a very beautiful ſtructure; and hence I preſerve it in my collection as a thing very worthy of contemplation. One doubt may be ſtill objected to the hypotheſis that I have advanced concerning the odiferous impregnation of the female Bee, and that is, that the female at the time of coition may thruſt the extremity of the vulva into the body of the male, as is evidently the caſe with ſome ſpecies of Flies. But I anſwer to this, that the extremity of the uterus in this female is not made in the ſame manner as it is in thoſe Flies: beſides that theſe arguments, by which I have before alledged that the male cannot eaſily approach the female, and that no coition can be performed amongſt the whole ſwarm of the buſy and noiſy Bees, ſtill remain unſolved. To which add, that it muſt be firſt very evidently proved, that the aperture obſerved by me about the horny little bone in the root of the penis, out of which I expreſſed the ſeed, is natural, and in its natural ſtate is emitted ſo far out of the body. Nay, and if all theſe ſuppoſitions were taken for granted, yet it would be hard to demonſtrate that this coition of the Bees is like that which obtains among thoſe Flies. The coition indeed of the Hornets, which is nearly related to the Bee kind, ſeems likewiſe to contradict this opinion. But, perhaps, ſome will rather maintain, that as ſoon as the female hath broken its cell, the male immediately creeps into it, and begins to copulate with her while yet in the cell. And among many other reaſons this may be alledged as one, why the cells of the females are much larger than thoſe of the other Bees. But all theſe matters are merely conjectural, and they are not only contrary to the ſtructure of the genital organs, but they ought not, nor can ever be admitted as certain, only ſo far as they are eſtabliſhed by trial; nor can I think it is impoſſible to know by experiments how this female is impregnated. However, my opinion is, that this impregnation happens by means of the effluvia only; it remaining thus far ſufficiently ratified and confirmed. The female, therefore, at the time of ſwarming, becomes fecundated by only the ſeminal effluvia of the males, which diffuſes itſelf in the hive; and hence the tripple ſeed in the ovary of the female acquires its fertility; that is, ſome thouſands of the eggs, out of which the working Bees are produced, then ſome few eggs out of which the females are excluded, and ſome hundreds which produce males. But the two latter ſpecies of Bees are not generated in the hive until the year following, unleſs when the hive is to ſwarm again the ſame year; for then the males iſſuing from thence perform that buſineſs again for the ſubſequent year.

If the reader views the admirable ſtructure of theſe genital organs, and the exquiſite art conſpicuous therein, according to their worth and dignity, he will indeed ſee that God, even in thoſe minute inſects, and their parts, has concealed from the incurious eye, ſtupendous miracles; nor is it difficult to diſcover and illuſtrate theſe things, provided one ſeduloully applies to their inveſtigation. Conſider, therefore, what a progreſs acute and ſagacious geniuſes may make in theſe inquiries, if they will induſtriouſly ſearch into them. What I have hitherto deſcribed and exhibited, are indeed but light ſhadows of the things themſelves: it would be eaſy for ingenious perſons to diſcover and lay open all theſe things thoroughly and more perfectly, to the glory of the great God *. As to myſelf, I do moſt willingly confeſs that my capacity is ſo ſlender, that I am able to behold the works of God only at a diſtance. Nay, the more frequently I view them, the more I am convinced of my ignorance, and I know my own weakneſs and miſery.

To make what has been hitherto deſcribed the more intelligible, I ſhall add the figure of the genital parts of the great water Beetle, in which the teſticles are very remarkable for their ſtructure.

Tab. XXII. fig. v. *a*, the penis itſelf, which is ſituated in the midſt between the prominences of the horny part, and is inflated and erected in coition by the help of the blood.

b b, The horny part of the penis, in the middle of which it is placed, and is ſtrengthened thereby.

c c, The root of the penis formed in the ſame manner as in the Bee.

d, The teſticle of one ſide, as it appears at firſt ſight, when diſengaged from its pulmonary tubes.

e e, The teſticle freed of its pulmonary tubes, ſo that its internal ſtructure, which is tubular, or conſiſts of ſmall and round filaments, may be ſeen.

f f, The vaſa deferentia, whereof one extremity, as in man and brutes, iſſues out of the teſticles, or rather is joined to the tubulated filaments thereof.

g g, The vaſa deferentia dilated, or that part of them where they ſecrete a certain ſeminal matter, as well in man as in the Bee.

h h h h h h, The ſeminal veſicles with their curled extremities: theſe appear in that part not unlike the ſeminal veſicles in man.

i i, Veſſels cloſed at their ends, which open about the root of the penis, and probably perform the office of proſtrata in man.

Finally, to conclude this hiſtory of the anatomy of Bees, I ſhall ſubjoin a deſcription of the ſpinal marrow, and ſhall delineate it, and explain the figures. All other things which may be further ſaid of theſe inſects, ſuch as the deſcription of the bony or horny parts of the Bees, I ſhall paſs over at preſent in ſilence; for as the Bees have now employed me continually for ſome months, diſſecting in the day time, and writing at night, I am the more inclined to put an end to the preſent treatiſe, though I clearly ſee that ſome parts of this inſect may be ſtill much more accurately inveſtigated. However, I ſhould ſcarce believe that I have committed any conſiderable errors; therefore I confidently ſubmit to the cenſure of thoſe who have candour, and ſhall never refuſe to learn better things.

The ſpinal marrow of the male Bee, Tab. XXII. fig. VI. *a*, knotted in its beginning, or that part of the brain which in the deſcription of the eye diſſected before, I have ſaid was joined to or continuous with the brain, the cortical ſubſtance and tranſverſe fibres. This part, which gives origin to the nerves of the eye, is very eaſily ſeparated from the parts juſt now recited, if it be in the leaſt handled. I have not yet examined how the eyes are conſtituted in other inſects, and in the Silkworm, with reſpect to the brain or ſpinal marrow; I have delineated only their nerves as they appear in the Worm or Caterpillar, as may be ſeen in the figure which I have before inſerted in the hiſtory of the Rhinoceros Beetle; where is likewiſe ſeen very diſtinctly, the nervus recurrens, or recurrent nerve, which I have here afterwards obſerved in the Bee.

b b, 1, 2, 3, &c. Shew the ſeven ſubſequent little knots of the ſpinal marrow, into which the marrow, when it paſſes through the breaſt and abdomen, is dilated. Theſe ſame letters likewiſe ſhew the origination of the nerves from thoſe parts.

c c c c, Are ſome nerves which do not ariſe from the marrow where it is dilated, but from the diviſion of the two larger nerves which conſtitute the marrow.

d d d, &c. Are thoſe places where the marrow is divided or opens. This is never ſeen in man, nor in larger animals.

e, The part of the marrow ſituated in the head, and that in the neck. The part in the neck lies encloſed in a ſmall horny part.

f, The part of the marrow which is placed in the thorax, and there principally provides for the muſcular fibres that move the legs, wings, &c.

g, The part of the marrow encloſed in that narrow horny little part, by which the body is joined to the breaſt.

h, The part of the marrow ſituated in the abdomen, which gives nerves not only to the viſcera, but to the muſcles of the rings, and to the ſting.

i i, Two remarkable nerves diſtributed over the jaws, and other parts. They are the ſame that I have before exhibited in the figure of the eye.

k k, Two nerves reaching to the proboſcis or trunk, ſerving probably for the taſte.

l l, Two other nerves which are conveyed into the muſcles of the trunk. I could not yet inveſtigate the olfactory and auditory nerves in this creature.

m m, Two nerves tranſmitted out of the beginning of the marrow towards the eyes, as I think. This, however, I cannot aſſert for certain, as I do not love to deceive either myſelf or others, for it is a difficult thing to ſee this matter diſtinctly, becauſe the upper parts of the brain are here united to the marrow.

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* This author died before the invention of glaſs hives. Theſe have been carried to ſuch perfection ſince, that we can ſee the whole courſe of operations of the Bees carried on in it. It is thus we have diſcovered their true oeconomy.

n n, Two nerves ſent off from the thorax to the upper muſcles of the body, and together with the marrow encloſed in that narrow filament which connects the thorax with the body.

o o, Two ſtrong nerves, which are for the moſt part inſerted in the root of the penis, and other organs of generation, as has been ſhewn in the figure of thoſe parts.

Fig. VII. *p p*, &c. Part of the marrow repreſented ſomewhat magnified.

q q, &c. The external medullary ſubſtance, reſembling a divided nerve.

r, Another portion of marrow, put between its proper medullary ſubſtance; by the acceſſion or addition of which the marrow is dilated into a little knot. This is by no means ſo white as the medullary ſubſtance itſelf, but ſomewhat gray, and approaching to fleſh colour; therefore perhaps the marrow is by the intervention of ſuch a different ſubſtance dilated and made more firm, in order to ſtrengthen it for omitting its nerves. This may be likewiſe ſeen fig. VI. under the letters *c c*, where even the medullary ſubſtance itſelf becomes thicker: probably this dilatation ſerves alſo for another purpoſe; for that dilating matter ſeems to me to be of the ſame nature with the ſubſtance of the brain in this inſect, and agrees with the cortical ſubſtance, and the tranſverſe fibres. I ſhould in this place add a delineation of the pulmonary tubes, whereof theſe nerves have a conſiderable number, but that I am certain as adequate an idea may be had by the deſcription of them. That ſubſtance which is lodged between the medullary matter, hath been before me ſhewn by the juſtly celebrated Malpighius, in his excellent treatiſe on the Silkworm, and he has alſo delineated the pulmonary tubes there. I had reſolved to ſtop in this place, but upon reconſidering my obſervations, I found ſomething in them belonging to the hiſtory of the Bees, which I ſhall firſt explain. I ſhall in the firſt place give a brief hiſtory of the inſect called the Bee-hive Wolf, or Lupus Alvearius: this is an inſect, which, when it comes into the hives of Bees, ought to be conſidered as their deſtructive plague, becauſe it conſumes and eats all their wax. This creature, properly enough called Lupus or Wolf by the Bee-keepers, is a Vermicle like, as to form, to a ſmall Caterpillar. Tab. XXVI. fig. II. *a*, the body, computing the laſt annular inciſion of the tail, is divided into fourteen rings; on each ſide of the body are nine points of reſpiration; the firſt and laſt of theſe, which indeed I think are peculiar to the inſect, are as large again as thoſe that are placed between them. The pulmonary tubes are white, and appear diſtinctly through the body. The body itſelf is nearly ſmooth, being ſet only with a few ſcattered, thin, and oblong hairs. When this creature contracts itſelf, ſeveral regular whitiſh folds or wrinkles are produced in its ſkin. In the head are to be obſerved, the eyes, the teeth, one lip, ſome articulated briſtly hairs, and a papilla or nipple that ſerves for ſpinning. The whole Worm is fleſh coloured, except when the colour is ſomewhat changed by the contents of the inteſtines ſeen through the ſkin. It moves itſelf in the ſame manner as the reſt of the Caterpillar kind, and runs backwards and forwards with equal celerity: for this uſe it has ſixteen feet, that is, ſix fore feet, eight middle, and two hind feet. The fore feet are furniſhed with ſharp claws, and the middle and hinder feet ſhew a conſiderable number of ſmaller nails in the extreme circumference of their ſoles. This Caterpillar is produced from a ſmall kind of an oblong egg, which is laid in the combs by a grayiſh Butterfly *b* of the Moth kind. It is a very deſtructive Caterpillar that proceeds from this egg *a*, for it not only corrodes or gnaws the combs, becauſe it feeds on wax, which I think it has in common with the Worms of the Humble Bee; but wherever it paſſes, it likewiſe gnaws round holes through theſe waxen cells: by this means one Worm ſometimes breaks open and deſtroys fifty or ſixty ſuch cells. We muſt particularly obſerve, that this Worm, wherever it penetrates, always fabricates or forms an hollow and tubulated web *c c*, in which, as in a rabbit burrow, it can very ſwiftly paſs from one part to another, and very ſpeedily run back again. If you attempt to catch this Worm at that time, you will ſee it by the help of the claws, wherewith its hinder feet are armed, very firmly fix itſelf. Unleſs this creature be ſoon expelled, or be killed in the beginning by the Bees themſelves, and carried out of the hive, it fills the whole comb with ſuch webs, and turns itſelf in them every way into various bendings and windings: ſo that the Bees are not only perplexed and diſturbed in their work, for they frequently intangle themſelves by the claws and hairs of their legs in thoſe webs, and the whole hive is deſtroyed. That I might be able to inveſtigate more accurately the true nature of theſe little creatures, I have ſometimes given them food for a time. When I have for that purpoſe expoſed a comb of wax in a drawer of my cabinet to the open air in my chamber, the whole comb has been in a very ſhort time eaten up by numbers of ſuch Worms. But I always firſt obſerved many of their Butterflies fluttering about my chamber. Nay, I ſaw ſome of theſe Worms ſo famiſhed, that they devoured the ſoft part of the bodies of ſome dead Bees, which had ſtill ſtuck in the comb; nay, did not leave even their wings. They made very wonderful burrows, Tab. XXVI. fig. II. *c c*, through the comb. Beſides this particular Caterpillar, there is another ſmaller, that likewiſe iſſues *d* from a little ſpecies of Butterflies, and does great miſchief to the combs corroding and eating away the wax. This Caterpillar is not only deſtructive to the wax, but to the Bees themſelves, for it buries and kills many of them; but this happens only by chance. I ſaw one of theſe little

Worms, whilſt it was ſmall and was breaking the cells, in which the Nymphs of the Bees lie, and eating the wax there, cover the Nymphs alſo with its excrements, inſomuch that they could be ſcarce known. To this may be added, that the Worm itſelf, when, in order to get food, it creeps every where round about the Nymphs, compreſſes and deſtroys them : this miſchief is occaſioned chiefly by one that is more grown, the body of which demands ſomewhat more ſpace. I have learned theſe matters much againſt my inclination, and have been full of indignation againſt the Worm, when with its excrement it defiled and killed ſome Nymphs, which I had deſigned to obſerve in their changes.

As this Worm uſes wax for its food, its excrements are nearly of the ſame nature ; if they be received upon a thin plate of glaſs, and put over a burning coal, they melt at firſt like wax, but afterwards they harden, and like the burnt Bee-bread, become friable between the fingers. Theſe excrements are of a black colour, and of an hexagonal figure, and when chewed they exhibit a ſweetneſs and tenacity like wax: a tincture may be extracted from them by ſpirit of wine, ſuch as hath heen uſed to be prepared out of the excrements of ſome other animals, and then applied to medicinal uſes. Nor would it indeed be difficult to gather together a great quantity of theſe excrements; provided their uſe was known. After this Worm hath eaten ſufficiently it forms, Tab. XXVI. fig. II. *e*, to itſelf a new oval white web, and encloſes itſelf therein, ſometimes covering the circumference with its excrements. Sometimes each of theſe Worms weaves ſingly, and ſometimes forty or fifty of them perform this work together : in ſome time afterwards they are changed into Chryſallides or Aureliæ *f*; ſo that we ſee they belong to the ſecond method of the third order of natural transformations or accretions in the parts. Finally, theſe Worms having acquired the figure of Chryſallides, caſt their laſt ſkin in their webs, and at length creeping out of them appear winged animals *d b*, and aſſume the perfect form of their parent Butterflies. Theſe frequently pitch about the doors or other openings of hives, and as it were ſollicit admiſſion, but they are very aſſiduouſly kept out by the Bees: they are indeed formidable enemies to the Bee, though theſe and all other ſpecies of Moths, are very weak creatures, which may with the fingers be eaſily reduced to duſt. The Bees, however, do theſe Butterflies no miſchief, unleſs when they by their irregular flying, which is common to almoſt all Butterflies, ſtrike the Bees with their wings, or when they too obſtinately attempt to creep into the hive. The ſmaller ſpecies of theſe Moths is of a grayiſh colour, and has four ſomewhat glittering wings, ſix legs, and two long and ſharp-pointed antennæ or horns placed juſt over the eyes. The other ſpecies which is larger is of a more dusky colour, and has wings ſomewhat ſpotted, in the middle of which, or in that part where they reſt upon the body, are ſeen on each ſide three ſmall eminences, compoſed of feathered little ſcales, formed in the ſame manner with all the reſt of the Butterfly ſcales; for they are not real feathers which produce theſe wonderful and very beautiful colours of the wings of thoſe creatures, but rather ſcaly little parts ſupported by little ſtalks. Aldrovandus hath delineated this ſpecies of Butterflies, and he gives it the name of the hive Moth.

One may ask naturally why the Bees ſuffer theſe Worms, which deſtroy and conſume their workmanſhip ſo terribly, to live in their hives ? and this ſeems the more ſtrange, becauſe the Bees kill their own males about the end of auguſt, break their wings with their teeth, and carry them out of the hive, nor do they leave them, till they are perfectly dead. Nay, they do not admit other Bees, nor ſuffer Hornets to enter their hives. The ſolution of this queſtion is eaſy and obvious, for the principal reaſon conſiſts in this, that the female is then either barren, or does not lay eggs enough, and conſequently does not multiply the number of the Bees as ſhe ought to do, or is perhaps mutilated, maimed, without wings, or weakened by ſome other means. When theſe things happen, as the working Bees have no Worms to feed, or whoſe cells they ſhould build, or even when the hive is too large, on account of the ſmaller number of the Bees that inhabit it, than is requiſite to contain them and their iſſue; on any of theſe accounts the progeny of the Bees occupies the upper part of the hive, and the working Bees, throwing off all care of preſerving their cleanlineſs and neatneſs, lead a careleſs, idle, and irregular life, and gather but little honey; nay, if the males be in the hive, when in this condition, they by no means kill them, for they have nothing to mind or take care of but feeding themſelves, and they throw off all affection for the preſervation of their progeny, and have too much time to fly about and provide for themſelves ; therefore, having no occupation, they live very diſorderly, and will leave their males alive till the winter is far advanced *. In this caſe they let the moths enter unoppoſed ; they will likewiſe ſometimes creep underneath into the hive, that they may lay their eggs in the wax. This happens chiefly when the Bee keepers neglect to ſtop up on every ſide the lower verge of the hive, though the Bees themſelves ſometimes take care of this matter. When therefore the Bee-keepers ſee a hive fallen into this misfortune, which they may eaſily perceive, or indeed prevent, provided they now and then turn up and thoroughly examine the hive, it is their buſineſs inſtantly to cure it. The Wolf Caterpillar is to be expelled from the hive, by cutting and breaking open the unfiniſhed wax; and if the female be ſick ſhe muſt be killed and the Bees put into another hive. If in this other hive there be too ſmall a number of Bees, two or three hives muſt be put together, the Bees aſſociated, and to avoid new confuſion one of the females muſt be likewiſe killed: the working Bees muſt be compelled by ſome of theſe means to mind their duty; and this may be very eaſily done, ſince they follow nature as their guide, and need no other maſter. Beſides this Caterpillar produced from the Moth kinds, there are other creatures that are enemies to the Bees, whereof Virgil in Georg. IV. ſays,

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* Among the moral virtues attributed to Bees, none is more celebrated than that of their burying, as it is called, their dead. Thoſe who firſt eſtabliſhed this opinion, ſaw Bees carrying others which were dead to a diſtance from the hive, but Reaumur has explained this, and robbed the creatures of the glory they had retained for their ſuppoſed charity through centuries. It appears from the moſt ſtrict examination, that this is done in care for themſelves, not in regard to the dead. They often murder thoſe they thus carry out, and when the ſtores are likely to fail, they will kill even the Worms and Nymphs, and throw them out of the hive. They carry them to a diſtance, becauſe they hate a ſtench.

For lurking Lizards often lodge, by ſtealth,
Within the ſuburbs, and purloin their wealth,
And Lizards ſhunning light, a dark retreat,
Have found in combs, and undermin'd the ſeat:
Or lazy Drones, without their ſhare of pain,
In winter quarters free, devour the grain;
Or Waſps infeſt the camp with loud alarms,
And mix in battle with unequal arms:
Or ſecret Moths are there in ſilence fed,
Or Spiders in the vaults their ſnary webs have ſpread.

Dryden's Virgil.

It is a common opinion that the Bees in rough and boiſterous weather, and particularly in a violent ſtorm, carry a ſtone in their legs, in order to preſerve themſelves by its weight againſt the power of the wind. Hence Virgil in Georg. IV.

Nor dare they ſtay,
When rain is promiſed, or a ſtormy day:
But near the city walls their watering take,
Nor forage far, but ſhort excurſons make.
And as when empty barks on billows float,
With ſandy ballaſt ſailors trim the boat;
So Bees bear gravel ſtones, whoſe poiſing weight
Steers through the whiſtling winds their ſteady flight.

Dryden's Virgil.

But this, as Clutius juſtly obſerves, has not been hitherto remarked by any Bee-keeper, nor indeed have I myſelf ever ſeen it. Yet I ſhould think that there may be ſome truth in this matter, and probably a certain obſervation, which I ſhall preſently mention, has given riſe to the ſtory. There is a ſpecies of wild Bees not unlike the ſmalleſt kind of the Humble Bee, which, as they are accuſtomed to build their neſts near ſtone walls, and conſtruct their habitations of pieces of ſtone and clay, ſometimes carry ſuch large ſtones, that it is ſcarce credible by what means ſo tender inſects can ſuſtain ſo great a load, and that even flying, whilſt they are obliged to ſupport alſo their own body. Their neſt by this means is often ſo heavy as to weigh one or two pounds; though only ten or twelve young Bees are brought up in it. This I have obſerved in the year 1666, at the country houſe of Mr. Thevenot, ſituated in the village of Iſſy, not far from Paris, near the bottoms of ſome windows, in the preſence of Dr. Steno. In this neſt I at that time found a red Worm, with ſix legs, Tab. XXVI. fig. 111. *a*, which was changed into a Nymph *b*. But this Nymph after in the ſpace of a whole year did not change into a Bee, but into a very beautiful Beetle *c*; nor could I in the mean time obſerve that this Worm, in all this time, took any conſiderable food, unleſs perhaps the ſtony and clayey particle of this neſt ſerved it for food. See further the explanation of the figure. Beſides, I likewiſe found there a ſingular kind of Waſp, and in ſome oblong hollowed tubes, I alſo found the membranous webs of Bees already broke open and deſerted. From all theſe appearances it is therefore evident that 'tis poſſible Bees may be ſometimes ſeen to carry little ſtones, but theſe were not common Bees, nor have I hitherto found that any perſon has obſerved this practice in them. The neſts juſt mentioned were likewiſe known to the learned Aldrovandus, but thoſe he ſaw were made as it were of clay only, as may be ſeen in his remains or chronicles, where he rudely delineates the Worm of the little Bee, together with the neſt, and relates that Ariſtotle alſo, in Hiſt. Anim. Cap. 24. makes mention of this ſpecies of Bees; but as Ariſtotle in writing his hiſtory did not apply himſelf to anatomy, he could therefore ſcarce advance any thing certain; and hence it has ariſen that his account is very confuſed, for he undoubtedly compiled it from the relations of others, and this often leads into the greateſt errors. Indeed, nobody can accurately underſtand theſe my obſervations, unleſs he hath borrowed light from the experiments themſelves *.

As Bees frequent only herbs, plants, trees, and flowers, carefully avoiding ſuch things as are ever ſo little ſtinking or foul, and therefore are never ſeen to light, much leſs make any ſtay upon the dead carcaſſes of animals; the account given of Sampſon in the book of Judges chap. xiv. is a paradox with ſome, whilſt others look upon it as altogether incredible. Sampſon, according to that hiſtory, having killed a young Lion, found in ſome days after a ſwarm of

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* In ſwarming, one Bee with its fore legs lays hold of the hinder legs of the Bee next above it, and ſometimes they uſe only one leg for this purpoſe, laying hold only of one of the hinder legs of the Bee next above. In this manner they hang from the bough, or whatever other ſubſtance the firſt has fixed upon; and this firſt ſupports the weight of all the reſt. The whole cluſter, though ſingly they are light, is of conſiderable weight, and by this we may form ſome idea of the ſtrength of this inſect.

Bees, and a quantity of honey in the Lion's carcaſs *. However ſtrange this event may appear, even to the ingenious and ſagacious obſerver of Bees, I can diſcover nothing like a paradox in the relation. The context clearly proves that the thing happened in the midſt of ſummer, at which ſeaſon the carcaſs of any animal that had periſhed by a violent or natural death, would in a ſhort ſpace of time be ſo entirely cleared of its fleſh, as to form no more than a ſkeleton. In this the Bees might find a commodious habitation. Is it not a common thing to meet on the roads with the ribs and other bones of dead animals, ſo thoroughly ſtripped of the fleſh, and at the ſame time covered with part of the ſkin ſo dried, and in a manner tanned, by the weather, that inſects may find under it ſufficient ſhelter and convenient lodging? No doubt: the text runs as follows: After ſome days Sampſon found a ſwarm of Bees in the Lion's carcaſs. We muſt, indeed, underſtand by theſe words, that the interval between his killing the Lion and finding the honey in its carcaſe was not very long; nor is there any occaſion for underſtanding them otherwiſe, ſince at the time that Bees ſwarm, there are many inſects, eſpecially the Worms from which the common Flies ſpring, which, from their ravenouſneſs and great numbers, may devour, in a few hours as I may ſay, the carcaſſes of dead animals to the very bones. There are many ſpecies of Flies that will ſmell a carcaſs at a great diſtance, and immediately depoſit their eggs on it, as a proper place for their little Worms when hatched, as they very ſoon are, to find a food ſuited to their nature. It is almoſt incredible how faſt theſe Worms will grow, and how ſuddenly they will eat up all the fleſh of a carcaſs. I have experienced this by hanging a dead Duck to the branch of an apple-tree, at the ſeaſon when Bees ſwarm: in three days after the Worms have ſuddenly broke from their eggs, the Duck's fleſh and entrails have been entirely conſumed, nothing remaining but the bones and a few tendons, ſo that with very little pains it might have been formed into a perfect ſkeleton. We ſee in this inſtance how greedily theſe Worms devour, and how faſt they grow, immediately upon leaving their eggs. The ſame obſervation alſo has been before made by that curious naturaliſt, the illuſtrious Redi, in his experiments concerning the generation of inſects. His words are theſe: “ What was moſt “ ſurpriſing, the Worms were ſo much grown “ by the next day, that they each weighed “ about ſeven grains; whereas before twenty “ or thirty of them did not exceed one grain. “ The other Worms that ſtill continued to “ come from the eggs began, as I may ſay, in “ the twinkling of an eye, to devour what “ fleſh remained on the Fiſhes, ſoon leaving “ the bones quite bare like ſo many ſkeletons, “ that would not have ſhamed the hands of the “ beſt anatomiſt in Europe.” I remember that as I was once travelling on a very hot ſummer's day through the province of Utrecht, in my way to Culemburgh, in order to make ſome obſervations on the Ephemerus, I took notice of a dead Horſe that lay by the ſide of the road, and was ſo full of Worms, that no part of its fleſh could be any longer diſtinguiſhed; nor was the number of theſe inſects more ſurpriſing, than the waving motion they produced in the remains of the fleſh, bowels, and other parts of the carcaſs, which by that means appeared in a manner ſtill poſſeſſed of life and motion. A great number of the Worms, unable to find room and nouriſhment in it, were then crawling on the road, where the heat and duſt ſoon ſtifled them. Another time I had an opportunity of obſerving to what a degree of perfection theſe are poſſeſſed of the ſenſe of ſmelling; for having put ſome little Worms hatched from the eggs of Bees into a box, in order to trace and examine, if poſſible, their change into Bees, a few of them died; they were no ſooner dead, than, the box not being well ſhut, ſome little Flies took notice of their carcaſſes as a proper nidi for food and ſhelter to receive their eggs. Accordingly I had Worms produced in them in a very ſhort time, which at length changed to that ſpecies, which I call the fourth order of natural mutations, and in a few days after perfectly reſembled in ſize, ſtructure, and form, the Flies from whoſe eggs they were originally produced. Things of this kind occur moſt frequently in very hot ſummers; for then both the Flies and their Worms are multiplied in a ſurpriſing manner. When the bones of animals have been once cleared from their fleſh in the manner already mentioned, it is no difficult matter to conceive how they may in a little time be ſo waſhed by rain, as ſcarce to be diſtinguiſhable from the pureſt ivory.

As then it plainly appears by the hiſtory of Sampſon, that his adventure of the Lion happened about the time when Bees ſwarm, make their combs, and fill them with honey, we muſt of courſe ſuppoſe it was during the great heats of ſummer, when Flies lay their eggs; ſo that the offspring of theſe eggs might, in all probability, have devoured the fleſh and entrails of the Lion, within the time requiſite to ſolve all the difficulty that can be ſtarted upon this occaſion; beſides, alternate rains, ſunſhine, and dew, may be eaſily ſuppoſed capable not only of bleaching, as already ſaid, but of purifying alſo, and freeing from all manner of ſtench, or diſagreeable ſmell, the bones that remained, ſo as upon the whole to make the carcaſs, or rather

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* The conſtruction of the cells of the Willow Bee is very extraordinary, nor are theſe found in combs: they are frequent in our fen countries. I have ſeen thouſands of them in Lincolnſhire; the Worms make themſelves caſes of the leaves, and bury themſelves in the rotten part of the wood. The Worm of the working or hive Bee is a very weak creature, but theſe are vigorous and active: they wrap ſeveral entire leaves round their bodies, and faſten up the ends of this hollow cylinder with pieces of other leaves gnawed off for that purpoſe, and ſtuck together with a kind of wax, made principally from the buttons of water flowers. Thus they lie covered and buried till their change. This ſhews nature uſes various methods.

the skeleton of the dead Lion, a proper place of reception for thoſe little cleanly animals. We are not to imagine with the generality of mankind, that Bees at the time of their ſwarming ſend out before them as it were ſome of their nobles or courtires, to prepare lodgings fort he reſt of the company; by no means: the whole cluſter ſeizes the firſt opportunity of fixing themſelves, be it houſe or tree, or the corner of a wall, no matter whether high or low; and if they do not find their ſituation agreeable, or if no body comes with a hive to receive them, they ſoon fly off again, and ſo ramble about from place to place, till they find of themſelves, or till ſome one offers them, a convenient habitation. And thus it is probable that Sampſon's Bees had acted, till they at laſt ſettled in the Lion's carcaſe, where they built their combs and depoſited their honey: God himſelf, who governs all things, and from whom this work, or, as the holy writings expreſs it, Sampſon's conduct proceeded, directing the motions of theſe little inſects, ſo as to afford a ſubject for a riddle, and conſequently a juſt excuſe for delivering his people. I had once an opportunity of obſerving how irregular Bees will ſwarm, in a houſe belonging to Mr. John Oort, now magiſtrate at Nieuwenrode, that had greatly ſuffered by fire. I found the ſwarm in one of the remaining walls, where they had made both wax and honey; but their choice of this place was highly imprudent, for the hole by which they were to go in and out of their habitation was ſo large, that they could not by any means keep off the winter's cold, and their number alſo ſo ſmall, that they had not provided food enough to ſubſiſt them at home on the ſevere days when they could not go abroad. Sometimes I have ſeen ſwarms of Bees hanging to the topmoſt branches of the loftieſt trees, and at other times, content with ſo humble a ſituation, that the cluſter their ſwarm formed in a manner touched the earth.

It is probable that the not rightly underſtanding Sampſon's adventure of the Lion, gave riſe to the popular opinion of Bees ſpringing from dead Lions, Oxen and Horſes; and this opinion may have been conſiderably ſtrengthened, and indeed in a manner confirmed, by the great number of Worms that are often found during the ſummer months in the carcaſſes of ſuch animals, eſpecially as theſe Worms ſomewhat reſemble thoſe produced from the eggs of Bees. However ridiculous this opinion muſt appear, many great men have not been aſhamed to adopt and defend it. The induſtrious Goedaert has ventured to aſcribe the origin of Bees to certain dunghill Worms, and the learned de Mei joins with him in this opinion; though neither of them had any obſervation to ground their belief upon, but that of the external reſemblance between the Bee and a certain kind of Fly produced from thoſe Worms. The miſtake of ſuch authors ſhould teach us to uſe great caution in our determinations concerning things which we have not thoroughly examined, or at leaſt to deſcribe them with all the circumſtances obſervable in them. Therefore, although this opinion of Bees iſſuing from the carcaſſes of ſome other animals by the power of putrefaction, or by a tranſpoſition of parts, be altogether abſurd, it has had notwithſtanding many followers, who muſt have in a manner ſhut their eyes in order to embrace it. But whoever will attentively conſider how many requiſites there are for the due hatching of the Bee's egg, and for that inſect's ſubſiſtance in the Worm ſtate, as has been particularly explained in the preceding pages; whoever, I ſay, conſiders all this with the attention it deſerves, cannot be at a loſs for a clue to deliver himſelf out of that labyrinth of idle fancies, and unſupported fables, which, entangled with one another like a gordian knot, have even to this day obſcured the beautiful ſimplicity of this part of natural hiſtory. Nor need we complain that by overturning this ſyſtem, we loſe examples by which many moral precepts may be enforced; there will remain a ſufficient number of ſolid obſervations to anſwer the ſame purpoſe. Thus mutual love, friendly cohabitation, and uninterrupted courſe of good offices, obſervable amongſt Bees, who behave in all this as if they were actuated by chriſtian principles, and lived in a real communication of all good things, with their induſtry, by which their happineſs is conſtantly encreaſed, are powerful motives to engage us in the ſame practices. It is this love, this communion and diligence, that governs, ſupports, gives motion and life to their little republicks; and if we contemplate the inſtitutions of the primitive chriſtians, we ſhall find they lived in the ſame manner.

It is a difficult matter to determine any thing in regard to the period of life which nature has alotted theſe inſects *; at leaſt I muſt own that I have not as yet been happy enough to hit upon any ſatisfactory experiments on this head. Some perſons who have made Bees their ſtudy, affirm as a certainty that working Bees live but one year, and I am not averſe to their opinion, though I do not think they have as yet any ſure obſervations to ground it upon. On collecting all the Bees that die in a hive in one year, we find their number equal to that of the ſurviving. In autumn and winter, when the Bees neither fly abroad, nor carry their dead out of the

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* The Bee, which is ſo able to defend itſelf in the perfect ſtate, is, while in the condition of the Worm and Nymph, liable to deſtruction by that moſt contemptible creature the Mite. Millions of theſe get into the *hive*, whoſe paſſage would be deſperately defended againſt larger aſſailants; and they make their way into the cells and devour them. This was firſt obſerved of a kind of Bee that breeds in rotton willows, and the account is given at large in the Philoſophical Tranſactions. It has ſince been diſcovered in the common kind; and the miſchief has been often done where it was not ſuſpected how.

hive, an idea may beſt be formed of the degree of mortality that prevails amongſt them: at thoſe times their dead carcaſſes are found at the bottom of the hive by handfuls together. Now, if by adding to thoſe that die in this manner, all ſuch as fly off and never return, or that periſh in the fields in cold and rainy weather, or are devoured by Swallows and Dragon-Flies, daſhed by the wind againſt the leaves and branches of trees, or entangled in the webs of Spiders, we may eaſily gueſs that a far greater number of them periſh within the year, than thoſe which are to be found alive in the hive. We likewiſe obſerve in the autumnal ſeaſon, that the wings of Bees are often mangled, broken and wounded, and they appear ſo alſo in the beginning of the ſpring; whereas at the time when they ſwarm, their wings are ſound, entire, and in good order: all this makes it more probable, that Bees live but one winter, or from one ſeaſon of ſwarming to another. They may ſometimes, however, be obſerved to continue in the ſame hive for years together, provided part of the wax is now and then taken away; but this happens in the ſame manner that in great and populous towns the number of inhabitants is kept up by thoſe who come by degrees into the world, and inſenſibly ſucceed ſuch as ſickneſs, accidents, or old age, carry off. Beſides, the working Bees which have outlived the ſwarming ſeaſon and the winter, have performed the task aſſigned them by nature, namely, that of keeping each other warm in the cold weather, and nurſing the riſing generation: which neceſſary tasks being done, it it found that all other inſects hitherto obſerved, and ſome a little ſooner, and others a little later, periſh. Thoſe for example which immediately ſhed all their ſperm, diſappear before the reſt; as is plain in the Ephemerus, whoſe eggs are arrived at their full perfection from the very birth of the parent, and ſo provided for by nature, as to render the parent's care of them altogether needleſs, whereas other inſects muſt live longer, either becauſe the maturation of their eggs requires ſome time, or becauſe their eggs require a ſlow hatching. This is the caſe with the female of the Bees, and ſome other inſects; hence we may very probably conclude, that the female of the Bees lives longer than the working kinds, as it is impoſſible that ſhe ſhould lay all her eggs at one time. However, it is not yet ſo certain as we might wiſh how long ſhe lives. I believe it might be eaſily known by following the advice of Clutius, and contriving to make her ſo that ſhe could be readily diſtinguiſhed; and the beſt way to do this, would be, I imagine, to make a very little puncture in her wings, or elſe to cut off ſome inconſiderable portion of them with a pair of ſciſſors, or otherwiſe to ſtain the edges of them with ſome oil colour. Thus we might ſoon learn in a certain manner, what ſpace of life nature has aſſigned to this little creature. I am of opinion that ſhe either dies, or grows barren at the age of two years. But it is by no means ſo eaſy to try this or any other experiment I can think of, upon other Bees, on account of their numbers, and our not knowing the exact time of their birth. The working Bees come into the world at almoſt every ſeaſon of the year; and although the young Bees appear in greater numbers at the ſwarming ſeaſon than at any other, yet they are hatched ſome earlier than others by one, two, three or four months; for ſome of them do not creep out of their eggs, till a long time after the ſwarming time; and this I have likewiſe found to be the caſe with the males. Add to this, that the female is very aſſiduouſly employed in laying her eggs ſo early as the month of March, which makes it neceſſary that ſome of them ſhould be hatched ſooner than others; and conſequently this renders any judgment we ſhould form of the length of their lives altogether uncertain; for how is it poſſible, where there are ſuch numbers, to diſtinguiſh between the old and the young? Certainly no one can do this: nor is there any poſſibility of alledging any thing certain concerning the natural extent of life allowed the male Bees, though I believe it ſcarce exceeds ſix or eight weeks: but I cannot affirm that I am ſupported in this opinion by any ſufficient experiments; and I fancy that if any can be made to aſcertain it, they will coſt a great deal of time and trouble. Some perſons have aſſured me that they have ſeen male Bees alive in winter, when the female Bee had not been ſo fruitful as ſhe generally is. Be this as it will, I can only ſay, that all theſe things deſerve to be more attentively examined; for as the male Bees every ſeaſon ſuffer a violent death, nothing as yet can be determined concerning the natural extent of their lives. In the mean time, as I have, ſaid I am not againſt the opinion of thoſe who ſuppoſe it but ſix or eight weeks. There are ſome obſervations which induce me to think it is thus, beſides thoſe general laws of nature, by which theſe little animals are doomed to die, as ſoon as they have executed the commiſſion given them by her of propagating their ſpecies; for this buſineſs being over, the male Bees become altogether uſeleſs. This is plain in the Ephemerus, and likewiſe in the Silkworm Butterfly, which generally dies the third day after laying its eggs, unleſs the ſeaſon happens to be cool, for then theſe inſects will live longer. I believe this is owing to a plain cauſe, that the vital juices of thoſe little animals who eat nothing during their appearance in this form, do not exhale ſo readily in cool as in hot weather, and conſequently the means of life longer remain.

I have made a collection of about three thouſand inſects, ſuch as Butterflies, common Flies, Beetles, Locuſts, Caterpillars, Worms, Chryſallides, water inſects, and others; amongſt which I muſt not forget to mention, ſix kinds of wild Bees *: the firſt of them is that which builds its neſt with ſmall ſtones, grains of ſand, and clay; and in this reſpect ſo much reſembles the Humble Bees, that we may indeed reckon it of their number. There is another ſpecies, Tab. XXVI. fig. IV. of a ſingular ſtructure: its head and thorax differ ſcarce at all from thoſe of working Bees; but its belly is altogether different, for this part is thick ſet with hairs of a yellowiſh red, ſo as to look as if it was ſprinkled with ſome liquor of that colour; its laſt ring is armed with three ſharp prickles, and there are two more points of the ſame kind on the ſecond of the rings forming the belly. Its legs are covered with yellowiſh hairs, but that which grows under the horns, on the fore part of the head, and between the diviſions of the breaſt and belly, is almoſt white; as to the length and bulk of the body, it nearly agrees with the female of the working Bees, except that it is ſomewhat ſhorter. The third ſpecies, fig. V. is of a thicker and more compact body, and in ſize and ſtature nearly reſembles the male of the working Bees, but it has ſhorter wings; its head and eyes are formed in the ſame manner with thoſe of the working Bee; but under each antenna there is a yellow ſpot, which may ſerve as a mark to diſtinguiſh this ſpecies; beſides, the upper part of its trunk is coloured. The breaſt and head are covered with gray hairs, and the extreme joints with pretty long hairs of the ſame hue, but ſomewhat darker. The fourth ſpecies, fig. VI. is remarkable chiefly becauſe its antennæ or horns are three times thicker and four times longer than thoſe of the working Bees. Its trunk alſo exceeds that of the working Bee in length and thickneſs. Moreover, all its back, or the upper part of the thorax, and ſome parts of the belly, are adorned with bright red hairs inclining to yellow. This circumſtance, with the extraordinary ſize of the horns, is the beſt diſtinguiſhing mark of this ſpecies. It is alſo one third larger than the working Bee. The fifth ſpecies, fig. VII. is on the other hand ſomewhat leſs, and differs in its colour, and the hairs growing on its limbs, from all other Bees. The hairs of its breaſt and legs are of a deep gold colour, and the two upper joints of its hinder legs, which are likewiſe the largeſt, are quite covered with hairs of the ſame kind and colour, but much longer; whereas there is no hairs at all on the lower joints. The extreme borders of the rings that conſtitute the belly are alſo adorned with the ſame kind of hairs, only that they are of a fleſh colour, and much ſhorter. The ſixth ſpecies, Tab. XXV. fig. X. is ſomewhat leſs than the working Bee; the hairs of its head and breaſt are of a more duſky colour than thoſe of the Bees before deſcribed. On the other hand, its belly conſiſts of blackiſh rings of a ſubſtance between bone and horn, and ſtreaked on each ſide with little lines at ſome diſtance from each other. The coverings of the legs, which are of the ſame ſubſtance with the rings of the belly, are yellow, and the legs themſelves are thicker than thoſe of working Bees or Waſps, which makes me imagine that this little creature is provided by nature with no ſmall degree of ſtrength. All theſe ſix ſpecies of inſects agree with the three other kinds mentioned before, in this, that they have all ſix legs, four wings, and two antennæ or horns, and are divided into the head, thorax, and body. There appear alſo in ſome of the ſpecies three ſmall and ſeparate eyes, beſides the two great ones. The ſix laſt ſpecies are very ſeldom found in ſwarms together; they generally ramble alone and by themſelves, which makes it probable that they do not dwell together like working Bees. They are ſeldom found in the fields, but often in flower gardens, where the flowers ſupply them with honey. As to their gathering of wax, ſome appear quite unfit for that taſk, on account of the great quantity of hairs that grow on their legs.

I preſerve alſo two kinds of Hornets, of different ſizes, which I therefore diſtinguiſh by the names of the greater and leſſer Hornet. They are eight times as large as the working Bee, and reſemble it much leſs than they do the Waſp. They have four wings, fig. IX. *a a*; the outer pair are fixed to the ſhoulder-blades, of three times a greater extent than the inner ones. They have alſo ſix legs joined to the fore part of the breaſt, and the extreme joints are armed with two ſharp claws *b b*. The head *c* is ſomewhat oblong, eſpecially when the teeth or jaws lie cloſe together. The eyes are formed like a creſcent, and above in the interval between them there are three ſeparate ſmall eyes, under which there are two horns. The Hornets have likewiſe two very ſtrong teeth or jaws, divided into a great many very ſmall ones, and between the two principal teeth they carry a very ſhort trunk. The body is joined to the breaſt, which is pretty broad, by means of a very ſlender thread as it were, and conſiſts of ſix pretty ſtout rings of a ſubſtance between bone and horn. Theſe are yellow at the edges, but red on the upper part, and equally marked with dark brown furrows, from which on each ſide run eight ſpots formed as it were by the ſprinkling of a brown liquid, but on the ſecond and third ring, reckoning from the head, there appears a ninth ſpot, ſo as to form ſomething like a triangle. The head, breaſt, and legs, are almoſt of the ſame colour, and they are covered with very delicate hairs. The ſting is produced from the opening of the lower ring, Tab. XXVI. fig. IX. *d*.

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* Beſides the addition careleſs authors have made to the Bee kind, by ranking two winged Flies among the number, we have eleven diſtinct ſpecies in England. Mr. Ray, who was indefatigable in theſe reſearches, counts nine; and ſince this two others have been found. They are very ſmall, one is black entirely, the other black and red on the body: they make regular combs, and are found principally in the weſt of England. They build in cracks of rocks, in walls, or in very dry banks of earth.

Of the Waſp kind I preſerve nine different kinds, amongſt them is that which I found in the neſt I have already mentioned, as made by the Bees that uſe little ſtones for that purpoſe. The greateſt difference that occurs between the various kinds of Waſps, conſiſts chiefly in ſize and colour, though in one or two kinds there is beſides a great diſagreement in their ſtructure. But I ſhall not dwell long upon theſe particulars. The larger kind of Waſp is above three times as big as the working Bee, and has like them and Hornets, ſix legs, a proboſcis, two eyes, two horns, and four wings. The body of Waſps, as well as Hornets, converges to a point, and is ſhaped in the ſame manner with that of the particular Bee which vulgarly goes by the name of the king Bee. The rings of the body are variegated with blackiſh ſpots, and circular furrows upon a yellow ground. This general deſcription will, I hope, be ſufficient to ſhew what kind of an inſect the Waſp is. That repreſented in fig. VIII. is ſomewhat leſs than the largeſt ſpecies of all. Under it is to be ſeen another of a very ſingular ſtructure, fig. XI. *

I have beſides theſe eight kinds of Humble Bees or Bombylii, which differ from each other in ſize and colour. One kind has its body exceeding black, and is furniſhed with moſt beautiful wings of a colour between azure and purple. The largeſt kind is ſeven times as big as the largeſt working Bee; and this has a pretty long trunk. Its legs notwithſtanding are ſmall in proportion to its ſize. The head is ſomewhat oblong: the eyes are formed like a creſcent, and the horns lie directly between them. The breaſt is very broad, and it is covered thick with rough hairs; from the bottom of it ſpring ſix hairy legs, which if compared with the body, are very ſhort, and from the upper part of it riſe four wings; the inner pair very ſmall. The belly is very broad and hairy, and ſomewhat pointed on the lower part. The hairs that grow thus on the belly, are placed principally near the rings of it, and they are of a great variety of colours, as white, yellow, red, black, and others in ſome kinds; whereas in other ſpecies they are only of two. The Humble Bee, or Bombylius, of which I here give a drawing, Tab. XXVI. fig. XII. is of a middle ſize.

Of the Pſeudoſphecæ Ichneumon, or baſtard Waſps, I have by me twenty-five kinds. Theſe differ from each other in ſize, colour, and ſtructure. I refer them to the Waſps merely on account of the external reſemblance which ſome of them have to real Waſps, from which, however, in generation and diſpoſition they widely differ: moſt of theſe proceed from a Chryſalis, after having lived ſome time in the form of a Worm. Theſe alterations are performed in a very ſurpriſing manner; and as that from a Nymph to a Waſp takes up three or four weeks, the ſeveral gradations of it in point of colour, growth, and expanſion of members may be very accurately traced. Some of theſe baſtard Waſps which I preſerve in my collection, prey upon Flies; others upon Spiders, whoſe legs they break to pieces and then devour them. There is likewiſe amongſt them the Fly called Uniſata, or one briſtled, having one hair at its tail, and that which is diſtinguiſhed by the name of Tripilis or three-haired, fig. XIII. for theſe Flies are all baſtard Waſps: I cannot now treat particularly of them, as it would require a large volume. For the ſame reaſon I omit ſpeaking in this place of the diſpoſition, nature, method of propagation, and ſtructure of Hornets, Humble Bees, or Bombylii, and of the true Waſps; nor do I chooſe to ſay any thing of the inſects called Veſpatæ or ſhort Waſps, their building, houſes, and other remarkable particulars, of which I have ſome ſpecimens. I am poſſeſſed of a moſt curious Hornet's neſt, fig. XIV. and XV. as likewiſe of the male and female Hornet, the Worm from which they originally proceed, the web in which this Worm is encloſed, the exuviæ it caſts off on becoming a Nymph, and all the excrements it voids, together with the internal coat of the ſtomach and inteſtines. I can likewiſe ſhew the Nymphs of Hornets at various periods of their changes, and the rudiments of thoſe new colours which they by ſlow degrees attain. As to the internal parts of Hornets, I have the membranaceous net-work of a ſtomach of one, ſome pulmonary tubes, one of the ſilk or ſpinning bags, and a ſpinal marrow.

In my collection alſo are various kinds of Flies ſo like Bees, that ſome authors have called them by that name. Such is Goedaert and J. de May's Bee, which has only two wings. This is a ſufficient mark to diſtinguiſh theſe inſects from each other, though there are ſome Flies that have two pair of wings. Such is one in my muſeum, which is very beautiful, furniſhed with tufted antennæ, and in other reſpects like a Bee, only that it is a great deal larger. What is moſt ſingular in this Fly, is its proceeding originally from a water inſect. But as I have already ſaid an entire volume would be requiſite to deſcribe all theſe particulars; for which reaſon I ſhall here make an end of this treatiſe upon Bees. Certainly the nature, diſpoſition, and ſtructure of theſe inſects are ſo ſurpriſing, that they without ceaſing loudly proclaim God's goodneſs, wiſdom, power, and majeſty; and indeed all other animals, according to their ſeveral ranks, do him honour in the ſame manner, and conſtitute in the air, the water, and upon the earth, ſo many inſtruments and voices to publiſh his praiſes. I will join the univerſal choir, and ſay with the four and twenty elders in the Apocalypſe, "Thou art worthy, O "Lord, to receive glory, and honour, and "power; for thou haſt created all things, and "for thy pleaſure they are and were created." I ſhall conclude this long eſſay upon Bees with the words of the royal Pſalmiſt.

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* Some of the Bees breeds with us in the free air, not in a hive or comb. The young are bred up in the caſes of the lilac or other leaves; and there is ſomething very extraordinary in the manner of their hatching. The cells ſeem to cloſe up the paſſage of one another, and it would be thought the young creature in the hindermoſt muſt eat all the reſt to pieces to get out, for they are built in ſucceſſion after it: but though the whole caſe of cells be the work of many days, the young all hatch together; the eggs laid lateſt having obtained a forwardneſs in the body of the female, which make them diſcloſe their young as ſoon as the firſt.

> "Praiſe him all ye angels of his; praiſe "him all his hoſt." Pſal. cxlviii.

Some peculiar obſervations relating to the hiſtory of Bees.

A deſcription of a hive opened the tenth of March, with an account of the number of cells it contained.

ON the tenth of March laſt I opened a hive *, in which a young ſwarm of Bees had been ſettled during the month of June, the preceding year, but they all died in the intervening February for want of honey. I examined the cells built from the month of June till the winter ſeaſon, that is in the ſpace of about four months, and counting them one by one, I found them to amount to 22,574; and the whole of this prodigious number was only of that kind of cells, in which the working Bees are hatched and nurſed, or the honey and Bee-bread is ſtored up. Thoſe in which Bees had been already hatched, amounted to 7814; for it was very eaſy to diſtinguiſh them certainly from the others, by means of the ſkins and webs found in them, ſuch things being always left behind by Bees that have been hatched. All the other cells were formed for keeping honey, and the other cells are made to anſwer the ſame purpoſe, as ſoon as the young Bees contained in them have acquired wings to fly abroad.

It appeared likewiſe that all theſe cells were contained in nine combs, as they are generally termed, or nine portions of the whole wooden ſtructure, and theſe portions were large, oblong; of different forms, ſome diverging equally, others running out into two, three, or four angles. This variety in the figures of the combs is owing to ſome of them being built alone by themſelves, and others cloſe to each other; or to the neceſſity the Bees were under of keeping clear of the ſticks placed acroſs the hive to ſupport the wax, for this occaſions them to make their combs ſometimes of a triangular, and ſometimes of other forms. Nor can we perceive, that in this buſineſs the Bees obſerve any certain rule or order, ſince the figure of the cells themſelves does not ſuffer by this liberty they give themſelves.

Many of the little cells in which the honey was ſtored up, were twice as long as thoſe intended for neſts and nurſeries, and were alſo irregularly built, crooked, and full of angles. Even the ſides of the hexagonal cells did not every where exactly correſpond with one another, but here and there might be ſeen a gap large enough to contain a pin's head, a thing never to be met with in a truly regular comb.

All the half combs of cells on one ſide of the perpendicular foundation, which runs through the middle of them, and againſt which the cells are horizontally placed, were built full one half as long again as thoſe on the other ſide. There appeared here alſo many other irregularities, not to be ſeen in the cells that had ſerved the purpoſe of hatching, ſuch of them at leaſt as had been quite finiſhed.

From this prodigious number of cells, built between June and September, or October, we may entertain ſome idea of the great number of thoſe that the Bees conſtruct from the month of March to the June or July of the following year. I believe they may amount to 50,000, as this is the time for ſupplying with cells the male, female, and working Bees: but as yet I have not counted them.

A perſon fond of Bees, and whoſe account I could credit, once told me that he had a hive placed upon the bare ground, and exceedingly well ſtocked with Bees, inſomuch that to make room for their combs, they had hollowed out the earth under their hive, extended their conſtructions very deep into this hollow, and thereby encreaſed their numbers to a prodigious degree. But this is oftener practiſed by Waſps and Hornets, as theſe inſects naturally make their neſts under ground.

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* The danger of being ſtung by Bees may be in a great meaſure prevented by a quiet and compoſed deportment; and even when they have given the wound, the ſame ſedateneſs is the beſt conduct. A thouſand Bees will fly and buz about a perſon without hurting him, if he ſtand perfectly ſtill, and let them alone: but if he ſtrike at them, probably he will be ſtung. If this happens, he ſhould ſuffer the Bee to reſt upon his fleſh in quiet: if it be let alone it will draw out the ſting, and the conſequences will be leſs troubleſome; but if diſturbed, the ſting is left in, and the wound is much the worſe.

A hive

A hive opened the 14th of June, the number of Bees and Nymphs found in it, with a particular deſcription of many other ſingularities not as yet known.

IN the beginning of June I bought a hive of Bees, it produced a ſwarm the 14th of the ſame month. I received the young Bees in another hive, and put this hive in water the day following, with all its new inhabitants. By this means I found the ſwarm conſiſted of one female, four males, and 2433 working Bees, who had not made any wax ſince they ſwarmed.

The 16th of the ſame month, I likewiſe drowned in the ſame manner the Bees that remained in the original hive, from which otherwiſe a ſecond, and even a third, ſwarm might have been expected. In this hive I found one female, 693 males, and 8494 working Bees. While I was employed in counting them, I let the water run off from the hive, that I might afterwards ſatisfy my curioſity in aſcertaining the number of their cells, but I found the amount ſo great, eſpecially that of the cells belonging to the working Bees, that I thought proper to deſiſt, for fear of loſing the opportunity of making ſome other obſervations, that I imagined better deſerved my attention.

I therefore reckoned with great care and exactneſs the little dwellings of the female Bees, and found nineteen of them as yet building, but ſome a little more forward than others. There were beſides fifteen more, in ſhape reſembling a pear, and quite finiſhed, which were all cloſed up with wax, and curiouſly diſpoſed on the edges of the combs. Some of them ſtood by themſelves, others lay cloſe to each other, three, four, or five together. Others again were built quite cloſe to the cells of the male Bees; ſome were ſituated obliquely; others horizontally, ſo as to reſemble a beer glaſs lying on its ſide; and, in the ſame manner, all the cells of both males and working Bees. Some on the other hand were built in an inverſe poſition, with their openings looking downwards, as the cells of Hornets are generally found. Finally, I diſcovered the cell of a female eat through on the fore part, being that out of which the young queen Bee had eſcaped that led the ſwarm of the 14th of June.

In nine of the cells belonging to the females, which I found cloſed up as juſt now mentioned, there were as many female Bees arrived at their full ſize, and furniſhed with wings ready expanded; and ſome of them were ſtill alive. Some of theſe females were quite gray, and others of a ſomewhat darker colour, according to the time that had elapſed ſince they had changed their ſkins, and that which they were ſtill to continue within the cell. Not one of them had as yet attempted to open itſelf a paſſage to fly abroad.

In the other five of the covered and cloſed up cells belonging to the females, I found as many Nymphs of females. One of theſe five cells contained a Nymph, which already begun to grow gray on the back, and was upon the point of throwing off its old skin; but in the other four Nymphs there was no appearance of this colour, they being as it were ſtill in their infancy, and for the moſt part reſembling in whiteneſs the curds of milk. The eyes alone had by degrees acquired a watry purpliſh colour, and the ſame might be obſerved of the three diſtinct ſmaller eyes, which are more conſpicuouſly perceivable in the inſect, while it remains in this ſtate, than afterwards when grown to its full perfection.

Under the belly and tail of theſe Nymphs, I found the exuviæ and air tubes that had dropped from them, on their exchanging the form of Worms for that of Nymphs. I could alſo perceive the remains of their food, which on pouring water upon it looked like ſoft ſtarch, or gum tragacanth, beginning to ſwell; it was of the colour of pure amber, and of a ſomewhat ſubacid flavour.

In the upper part, under the wax with which theſe fourteen cells were cloſed up, I could diſcern the web which the Nymphs ſpread in that part, while they continue in the form of Worms. The upper web was very ſtrong, and made of diſtinct threads, but in the lower part of the cell it looked like a membrane; for at the time theſe Worms labour to ſhut up their cells with ſuch webs, they are obliged to move their bodies in every direction, and thereby rub their food, and perhaps too their excrements alſo againſt their work, ſo as to fill the intervals between the threads that compoſe it with a kind of glue, and thereby reduce its ſurface to an evenneſs like that of a natural membrane.

I opened beſides all the cloſed up and covered cells of the males; many of theſe cells were ſituated near thoſe belonging to the working Bees, and contained in a ſingle comb, hanging at the bottom of the hive. The reſt of the male's cells were built in the midſt of thoſe of the working Bees, with common party walls or partitions. Of theſe cloſed up cells belonging to the males, I reckoned in all 858. In 234 of them I found as many Worms, which had not as yet changed to Nymphs, but ſome of them were nearer that period than others. In 146 cells there was the ſame number of milk-white Nymphs, which had but juſt thrown off their ſkins. In 44 more cells the eyes of the Nymphs were juſt beginning to acquire a watery and light purpliſh colour. In 414 other cells I found as many Nymphs, whoſe eyes were of a deep purple. And laſtly, in the 20 remaining cells there were Nymphs juſt upon the point of ſhedding their ſkins, and appearing in the form of male Bees: the gray and hairy members of the young males appeared plainly in theſe, through the tranſparent membrane which ſtill encloſed them.

After this I reckoned all the other male cells, and found them to amount to 1508, of which 720 were entirely empty, the male Bees ſometime before hatched and bred up in theſe, having taken their flight; 268 more were not as yet perfected, nor had been uſed for hatching; 520 of the ſame cells, in which alſo no Worms had been yet hatched, were full of the pureſt virgin honey. I counted beſides all theſe 1701 empty oblong cells, which, though conſiderably bigger than the male cells, were not unlike them: neither had any hatching been performed in theſe, their form not being regular enough for that operation; therefore they could only ſerve to lay up honey. This circumſtance likewiſe makes me imagine that theſe oblong cells are not to be looked upon as male cells, but to be reckoned amongſt the ſtore houſes which the Bees build for their winter proviſions; for we find they make cells of the ſame oblong form, but like the cells of the working Bees, to anſwer that purpoſe.

The number of cloſed up cells belonging to the working Bees amounted to 6468, and in all of theſe I found Nymphs under the ſame variety of circumſtances with thoſe which I had found in the male cells. It is therefore needleſs to waſte words in explaining their different appearances, nor had I leiſure to count the numbers at every period of growth and ſtep towards their perfection: beſides ſome of theſe Nymphs began to have a very diſagreeable ſmell.

I reckoned alſo 210 cells full of Bees-bread, which was alſo heaped up here and there in the combs of the working Bees, in particular cells diſpoſed between thoſe which had Nymphs in them, or which were full of honey, but none of theſe bread-cells were cloſed up.

As to the remaining cells, thoſe newly built, as well as the empty ones, in which Bees had been hatched, and thoſe conſtructed the year before as ſtore-houſes for honey, or nurſeries, I had not time to count their prodigious numbers. Neither did I count the cloſed cells, which were diſpoſed in the upper part of the hive, and were now ready to burſt with honey. But my curioſity led me to weigh the honey itſelf, and I found it amounted to ſeven pounds.

In all this hive I did not meet with a ſingle egg, nor with any Worms, but ſuch as were full grown; ſo that by this time the working Bees muſt have got over the heavieſt part of their yearly labour, for there was no longer any neceſſity for building cells, or nurſing of young Bees, nothing more remained but the agreeable task of gathering honey for the ſupport of themſelves, and of the males and females, and making preparation for the ſecond, third, and fourth ſwarm, which I could eaſily ſee were to be produced from the different ſtages in which the Nymphs of the the future queens appeared, and from the different periods at which it was of conſequence neceſſary theſe ſhould make their appearance abroad. This induces me to believe, that the old females continue, even during the intervals of ſwarming, their labours for the propagation of the ſpecies, as I have already obſerved in deſcribing the hive opened on the 22d of Auguſt.

Many of the working Bees belonging to this original hive were ſtill of a grayiſh colour, which is a certain proof that they have not been long out of their cells. Nor did I obſerve one amongſt them that had loſt its wings; whereas ſuch crippled Bees are frequently ſeen in ſpring or autumn. This circumſtance makes it probable, that moſt of the laſt year's male Bees had been taken off by a violent or natural death, and ſucceeded by a new generation. Nor need this opinion appear improbable to any, for if on the 14th of June I could count 6468 Nymphs in one hive, and 2433 Bees in one ſwarm, we may eaſily gueſs what a prodigious number of Bees muſt be produced in the interval of time between March and June, and that between June and September; no doubt a multitude ſufficient to ſupply a hive with a number of new inhabitants, three times greater than that of thoſe which had poſſeſſed it the preceding year, or ſummer months, ſuppoſing them all to have unfortunately periſhed: the queen alone ſurvives a longer time, though I can ſcarce believe her life is of above two or three years.

As by what I have here obſerved, it plainly appears, that fifteen young female Bees had been produced in one hive, and in the ſpace of time required for one ſwarming; and as experience informs us that Bees ſeldom ſwarm in this country above three or four times, and that after the laſt ſwarm they kill their queens, which are then no longer of any uſe, we may conclude that at this time the old and impotent queen undergoes this fate, and is ſucceeded by a young one, better able to propagate the ſpecies. This opinion indeed ſtands in need of more experiments to confirm it, and ſuch experiments may be eaſily made by any one who is willing to ſacrifice a few hives to his curioſity.

It is ſurpriſing how tenacious of life Bees are; after the hive and all its inhabitants had, in conſequence of my orders, been kept under water for a conſiderable time, and I had begun to count them, as if they were pefectly ſuffocated, they began by degrees to recover life, as it were, and fly about the hive, ſo that I found myſelf under the neceſſity of cauſing them to be again put under water, and though I had reaſon to think none of them could outlive this ſecond ſubmerſion, yet there appeared many after it with ſigns of life, and ſome of them recovered themſelves ſo well as to live after this three days and two nights without eating.

That I may now exhibit at one view every thing, that I obſerved in the original hive, and in the ſwarm produced by it, and that the ſum of both Bees and Nymphs added together may be more diſtinctly known, I ſhall ſubjoin the following account:

One full grown queen in the ſwarm,	1
One full grown queen in the original hive,	1
Full grown queens in the cloſed up cells,	9
Full grown working Bees in the ſwarm,	2433
Full grown working Bees in the original hive,	8494
Full grown males in the ſwarm,	4
Full grown males in the original hive,	693
Nymphs of queens,	5
Nymphs and Worms of working Bees,	6468
Nymphs and Worms of males,	858

Theſe numbers added together make 18966 for the total number of all theſe little animals contained in a ſingle hive before it ſwarmed; at which time 2438 of them iſſued forth in ſearch of a new habitation.

The number of cells, the old and new built ones, thoſe which were ſhut up and contained Nymphs; the empty cells, and thoſe of working Bees full of honey *, or Bee's bread, all excepted, was as follows:

Cells of queens begun or finiſhed	34
Cells of males ſhut up, empty, and thoſe which, after the Bees had left them, were filled with honey,	2366
In all	2400

Do not all theſe particulars diſplay in a ſurpriſing manner the inſtinct, diligence, and dexterity, which it has pleaſed the all-powerful Creator to beſtow on theſe little inſects?

An account of ſeveral wonderful particularities diſcovered on opening a hive, that had a few days before received a young ſwarm.

HAPPENING to be in the country on the 25th of July, I obſerved a great ſwarm of Bees, which, on its hanging to an Elm, I ordered to be received into a hive; but in a little time they all left this new habitation, and fled back to the elm, where they hung entangled by each others legs. The female Bee had not dropt into the hive with the others: I was therefore obliged to have recourſe to another ſhaking; when having brought the female into the hive, all the reſt ſoon followed.

On the 26th of July the weather was tolerably good, with a bright ſunſhine; the 27th cloudy; the 28th and 29th rainy: on the 30th on examining the hive, I found at the bottom of it upon the ground where it ſtood, a piece of a honey-comb, which had fallen thither, either becauſe it had not been ſtrongly enough faſtened to the top of the hive, or becauſe too many Bees had lighted upon it at one time. This piece of a comb contained 418 cells of for the working Bees, ſome were building, and others were finiſhed, and there were alſo ten eggs ſticking to the wax by one of their ends. All the forenoon of the 31ſt it was rainy and about midday very cloudy and windy, with ſome rain. In the evening I ordered the hive to be taken into my chamber, in order to examine what the Bees had done in the ſpace of theſe ſix days.

But as I was afraid of being ſtung in this enterprize, I reſolved to have all the Bees killed before I went to handle or inſpect them, for this reaſon I fumigated them with a bundle of lighted matches rolled up in linen rags, to ſuch a thickneſs, that it would juſt fit in the upper opening of the hive. All my endeavours to kill theſe Bees this way were however to no purpoſe; for after plying them with this fume, from eight o' clock to eleven, lighting the matches from time to time, as they went out, the Bees continued alive; but they ſeemed grievouſly complaining of, and reſenting the injury offered them, with the moſt horrid noiſe and loudeſt buzzings.

The next morning all was quiet again, ſo I removed the hive, at the bottom of which I found ſome hundreds of Bees lying dead upon the ground; but the greateſt part of them were ſtill alive, and ſome of them were beginning to fly away. I therefore reſolved to fumigate the hive a ſecond time, and I gave its inhabitants liberty to eſcape while it was doing. For fear of being ſtung on this occaſion, I took a half pint bottle, and having rolled ſome ſoft paper about the neck of it, thruſt it into the opening of the hive, taking care afterwards to ſtop all gaps between the door or opening of the hive, and the neck of the bottle with more paper of the ſame kind. As ſoon as the ſulphureous vapour began to fill the hive, the Bees in the greateſt hurry and confuſion and with the moſt dreadful buzzing, ruſhed to the number of 1898 in a manner all at once into the bottle, which I then removed to ſubſtitute another in its place; and by repeating the operation in this manner, I at laſt ſo thoroughly accompliſhed my purpoſe, that not the leaſt noiſe could be heard in the hive.

Having then turned the hive upſide down, I found the queen lying dead, in appearance, upon the ground, and ſome of the others which had fallen upon the ground, killed downright and wet all over; whilſt ſome other Bees that had remained in the upper part of the hive, were quite dry, and when put into the bottles flew about as briſkly as if they had not received the leaſt harm.

I next poured ſome water upon the priſoners I had in the bottle; by this means they were all drowned in a very ſhort time. I then made my examination, and found the ſwarm conſiſted of 5669 Bees, and was therefore a very good one, according to the judgment I had formed of it on its firſt appearance. Nevertheleſs, as the ſeaſon was very far advanced, and the ſpot the Bees lighted upon very ill furniſhed with materials for making honey, I thought it worth while to ſacrifice them to the curioſity I had of knowing what work ſuch a number could perform in ſo ſhort a time, and withal in ſo unfavourable weather.

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* Maroldi, by the moſt careful examination, and on the reſult of the ſtricteſt calculation, has proved that the pyramidal figure of the bottom of the cell in a honey-comb is determinately and exactly that, in which the ſubſtance of the cell takes up the leaſt room, and the ſpace contains the greateſt viſible quantity of honey.

Among this great multitude, there was but one female Bee. The greateſt number of them were working Bees, which are neither males nor females; and there were beſides theſe and the female Bee already mentioned, only 33 male Bees, prepoſterouſly called by the vulgar hatching Bees; for the young Bees are hatched by the mere heat of the ſummer, and that which is cauſed by the perpetual hurry and motion of the old Bees flying about, or working in the hive. It is very remarkable that the bottle into which the firſt 1898 Bees driven out of the hive had been received, was thoroughly heated by the perpetual motion of theſe impriſoned creatures, and the warm vapours which exhaled from their bodies.

The number of waxen cells begun and finiſhed, including thoſe of the comb I had found on the ground on my firſt examining the hive, amounted to 3392: they were all of the ſame ſize and form, and were intended only for neſts to hatch the working Bees. In 236 of the cells ſome honey had been ſtored up, but it had been afterwards made uſe of, as very little could be then gathered abroad. It was no difficult matter to diſtinguiſh the cells thus made uſe of from the others, for they had received a yellow tincture from the honey depoſited in them; whereas thoſe which had not as yet been employed this way were of a ſhining white.

There were alſo 62 of theſe cells, in which the Bees had already begun to lay up their ordinary food or bread called erithace. This ſubſtance was of a changeable colour, between a yellow and a purpliſh red; but perhaps this tinge might be owing to the fumigation: the whiteneſs of the unemployed wax was in ſome parts alſo impaired by the ſame means; coloured and covered beſides with black ſpots.

In 35 cells I found as many eggs fixed in them at one end, ſo that including the eggs found in the comb, which had fallen to the ground as already mentioned, there were 45 eggs in all. There were beſides in 150 of the cells ſo many new hatched Worms, but theſe lay almoſt inſenſible and motionleſs. They were of different ſizes, the largeſt of them being very like that repreſented under the letter *c*, fig. xiii. Tab. XXIII. All theſe Worms were ſurrounded with that kind of food, which the moſt expert obſervers of Bees think is honey thrown up by the old ones, out of their ſtomachs. This kind of honey is white, like a ſolution of gum tragacanth, or ſtarch diſſolved in water, and is almoſt inſipid: it ſhews nothing remarkable on being viewed with the microſcope. In the Worms themſelves I could perceive pulmonary tubes of a ſilver whiteneſs running moſt beautifully on each ſide through their little tranſparent bodies.

I examined attentively the wax cemented by way of foundation to the top of the hive, but I could find no difference between that and the other wax of which the cells conſiſt. They appear both to have the ſame nature and properties. I could not, however, but admire this ſtrong union or faſtening; this ſubſtance being juſt ſpread upon the hive like a cruſt, and conſequently faſtened to it by a very ſmall portion of its ſurface; whereas the reſt of the wax hung perpendicularly from this foundation, without any lateral or other ſupport whatſoever, as if a wooden bowl were fixed to a plain ceiling by a ſmall part of its circumference.

This hive contained the rudiments of a great many more ſuch combs of wax, of an oval form, and full of cells on each ſide: the empty ſpaces left between the combs, for the Bees to paſs and repaſs, did not exceed half an inch in breadth, ſo that it is plain the comb I found open upon the ground, and in which I reckoned 418 cells, had been torn from its foundation by its own weight, and that of the Bees walking upon it. Hence it appears, with what good reaſon thoſe who keep Bees, place ſticks croſsways in their hives, that the combs may have the more ſupport; and accordingly we obſerve that in theſe hives, the Bees themſelves on each ſide ſuſpend their combs to theſe ſticks.

Conſidering the great multitude of Bees employed in building the waxen cells, which I have been juſt examining, there is no great reaſon to be ſurpriſed at their having done ſo much work that way, though the time they had to do it in was ſo ſhort; and the weather ſo unfavourable. But it is really aſtoniſhing to think how a ſingle female could lay ſo many eggs in the ſame ſmall interval, and withal depoſit every egg in a ſeparate cell, and there firmly faſten it. We muſt alſo allow ſome time for laying the perpendicular foundations. It is, moreover, very ſurpriſing how theſe eggs ſhould ſo ſpeedily turn to Worms, and how thoſe Worms ſhould grow ſo very ſuddenly to their ſtate of change. But I muſt now conclude, and I ſhall do it with the following account of what the hive I have been deſcribing contained.

33	males.
1	female.
5635	working Bees.
3392	wax cells, for the uſe of the working Bees.
45	eggs.
150	Worms.
62	cells containing Bees bread.
236	cells in which honey had been laid up.

The End of the FIRST PART.

THE

BOOK of NATURE;

OR, THE

HISTORY of INSECTS.

PART II.

A catalogue of the inſects, which are referred to the ſecond method of the third order or claſs of natural changes, called the Chryſalis.

I Now proceed to deſcribe thoſe inſects which belong to the third order, as the preceding; but which preſent their ſeveral parts leſs conſpicuouſly. For this reaſon, I judged that the preſent order of tranſmutations might be properly divided into two kinds or modes; though the one of them differ from the other only, as the ſchoolmen ſay, by accident.

Among thoſe inſects, which paſs through the ſecond method of the third order or claſs of transformations, and by force of the increaſing and ſwelling limbs, and other parts, by which the ſkin is at length torn or burſt open, aſſume the form of a Chryſalis, which exhibits to view all its parts, though more obſcurely than they are ſeen in the Nymph; I reckon, in the firſt place, the diurnal or day Butterflies[*], which are called Ulinders and Pennevogels by the Hollanders; and are diſtinguiſhed alſo by two or three peculiar names of Albuli (Witkens), Papiliones Butyracei (Botercapellen), and Cerdonus (Schoenlappers).

Of theſe diurnal or day Flies, ſome are heavy and ſlow, others lively and ſwift; ſo that they cut the air, and move various ways. I preſerve in my collection eighty-five ſpecies of thoſe; among which, there are thirty-four foreign ones from Africa, America, Braſil, Spain, France, and elſewhere.

Among the day Butterflies beforementioned, there are twenty-two very large ones, thirty-three middle-ſized ones, and thirty very ſmall.

I preſerve alſo ſome of their Worms or Caterpillars, ſeveral of their Chryſallides, and ſome of their Worms, which are partly Caterpillars, and partly Chryſallides. I can demonſtrate, in the ſtate of nature, in what manner the Butterflies are placed within their laſt ſkin; in which, when encloſed, we call them Chryſallides; and their parts, though ſtill very minute, may be yet diſtinguiſhed by their reſpective colours. I can ſhew how their wings begin to grow protuberant, after caſting this ſkin. I likewiſe preſerve ſeparate the claws, inteſtines, ſtomach, and trunk of the Butterflies. I can likewiſe exhibit to the eye after what manner all the colours of the future Butterfly are ſeen through this ſkin, when the Butterfly is about to caſt it, this being its laſt ſkin. I can alſo demonſtrate all the parts of the Butterfly already in the Caterpillar. I paſs over the mention of a great many other things worth obſerving, which I preſerve, on this ſubject, there being now no time to enumerate them at large.

On a proper occaſion, I ſhall explain the method by which Butterflies, with their wings at large, may be expreſſed and formed, in all their beauty, in plaiſter of Paris, without any colours. This I think an important piece of art, and it has not yet been deſcribed by any one that I know. I ſhall at the ſame time ſhew how Caterpillars may be filled with ſuet, with plaiſter of Paris, with air, and the like, and by this means be preſerved. This is effected in none more conveniently than in the rough and hairy Caterpillars, the colours of which are permanent, as I can exhibit to the eye by ſeveral ſpecimens.

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[*] The Flies produced from Caterpillars are of two kinds, diſtinguiſhed by the time of their flying abroad, and the form of their antennæ, or horns. They are called diurnal and nocturnal Butterflies, or more diſtinctly Butterflies and Moths. The Butterflies appear by day; and they have naked horns, terminated by knobs or buttons. The Moths fly only in the night, and their horns are feathery, and have no buttons at the end. The Fly repreſented Tab. XXXIII. Fig. VI. is a Moth, that Tab. XXXV. Fig. XII. is a Butterfly.

I ſhall likewiſe give the ſeveral methods whereby the wings of inſects may be variouſly expanded and diſplayed, in a form perfectly agreeable to that they have in nature. Upon this occaſion, I ſhall alſo teach by what means the wings of inſects, which are as yet hidden in their original folds, may be produced to light; and, when expanded, may be dried and preſerved at pleaſure.

If I further have leiſure and opportunity, I propoſe to deſcribe an art or management, to ſhew in what manner monſtrous and deformed wings are made to grow; and ſhall propoſe, with theſe things, various operations, relating not only to the accretion of theſe wings, but to the motion of the humours, which are conveyed through their veſſels. Finally, I ſhall alſo ſhew in what manner puſtules, tubercles, pimples, and the like irregularities, may be raiſed in theſe kinds of wings. I ſhall likewiſe ſubjoin many other, hitherto unheard of, curious experiments, which I hope will be uſeful to natural philoſophy, and to medicine. All theſe I am now obliged to paſs over with this ſlight mention, ſince they cannot here be treated of at large.

Whether or not the accurate Fabius Columna found out, with certainty, from the examination of the aliments, on which the Caterpillars, that are to be changed into Butterflies, live. What plants are like each other, in reſpect to their virtues? Is a queſtion worthy the inquiry. He tells us, that whatever different plants the ſame Caterpillar eats, are of the ſame nature and virtue. Other naturaliſts alſo affirm, that each ſpecies of Caterpillars has only one kind of nouriſhment ſuited to it; ſo that hence its own peculiar Caterpillar ſeems to be aſſigned to every plant on which we ſee them feed. From this, if it be ſo, it neceſſarily follows, that the different plants, which one and the ſame Caterpillar eats, muſt certainly agree in regard to their virtues; and many ſpecies of plants may by this means be conſidered, ſo far as medicine is concerned, as one. Others, on the contrary, deny the fact: nay, and experience itſelf teaches, as Mouffet very well obſerves, " That there are " a ſort of ſtrolling Caterpillars, which do not " ſuffer themſelves to be tied down to any " particular leaves or flowers; but boldly run " over and taſte all plants or trees, and feed " thereon at pleaſure." I have myſelf ſeen a Caterpillar, which eat the Braſſica, or Cabbage: likewiſe feed upon the leaves of a Mulberry-tree. I found it feeding on both, of its own accord. I ſtill preſerve alſo the egg of the Butterfly, into which this Caterpillar was changed. It is grooved or channelled, like an elegant piece of workmanſhip, and ſurrounded with a purple circle.

We ſee Aldrovandus has deſcribed one hundred and eighteen ſpecies of Butterflies, of the nocturnal and diurnal kind. Mouffet exhibits eighty-ſix. In the figures of Hoefnagel are found fifty. And the ingenious Goedaert, has given us deſigns of ſeventy-ſeven nocturnal, and eight diurnal butterflies. However, there is nothing to be found relating to theſe inſects in thoſe authors, beſide the ſimple metamorphoſis. Nay, Hoefnagel has given us only the figures. Goedaert has indeed deſcribed the Fly, hatched from the maggot found in cheeſe; but he explains it no further, than by a figure of the Worm, Nymph, and Fly; and he has given an inaccurate figure of the Worm.

But, what illuſtrious, what prodigious, what ineffable miracles of nature, preſent themſelves to the careful obſerver in the changes of theſe ſeveral inſects! It would have been much more uſeful, to have exactly, and according to nature, deſcribed only one transformation of any Nymph, for an example to be applied to all the reſt, than to have delineated the changes of all theſe Caterpillars, with their various colours, and their Nymphs: for, according to the other practice, the things which were moſt uſeful and neceſſary, remain untouched and neglected. I have, however, ſome reaſon to know, from my own peculiar obſervations before related, what may be done in this ſtudy; in theſe I have laid open, in ſome degree, the myſteries of nature, and clearly exhibited to view the adorable wiſdom obſervable in them. Indeed, if we ſeriouſly conſider what admirable phenomena remain to be further inveſtigated, and obſerved; and with what ſplendor, clearneſs, and beauty, nature exhibits herſelf in theſe inſects; and how ſwiftly, yet how regularly ſhe performs theſe great operations, we muſt own, certainly, that ſhe appears, as it were, to have expended the utmoſt ſtrength of her wiſdom on them, and to have no where ſo liberally, and clearly preſented her impenetrable and inexplicable miracles, to be viewed by thoſe who worthily ſtudy her works.

Whilſt the preceding ſheets were at the preſs, the incomparable anatomical obſervations of Dr. Marcellus Malpighius, profeſſor of phyſic and philoſophy, in Bologne, on the Silk-Worm, and its Butterfly, which the Royal Society of London, inſtituted to promote natural knowledge, cauſed to be publiſhed this year, 1669, were kindly ſent to me by the noble Thevenot, whoſe merit and zeal to promote natural knowledge, are ſufficiently known to all who happened to be at Paris, and preſent at the weekly diſputations inſtituted by him. And as the celebrated phyſician, juſt mentioned, ſeems to have attained, by his extraordinary accuracy, the end he propoſed to himſelf in theſe celebrated obſervations; we may particularly remark, that after that exact obſerver, Andrew Libavius, he is the only perſon who excludes the fancied metamorphoſis from the natural courſe of the changes, which the Silk-Worms undergo; and has publiſhed ſeveral things agreeable to truth: theſe, he confeſſes, became known to him by chance. I ſhall inſert his words, as being moſt true, and worthy of peruſal. " And at length, within four " days," ſays he, " in which time the heart of " the Silk-Worm continues moving ſlowly, " and the body is growing bigger, having thrown off the outward ſkin like a ſlough, the Aurelia appears as a new creature. The throwing off the old, and aſſuming this new form, is completed in the ſpace of one minute and ten ſeconds; and it is thus done, as I happened to ſee it. The motion of the heart is very quick at firſt, and the whole frame of the body appears convulſed; ſo that the ſeveral circular folds of the ſegments emerge, and by the tranſverſe conſtruction of the ſides, the external ſkin is ſeparated from the inner; hence, upon making an effort, and thruſting the body, which now appears particularly thick towards the head, the ſkin is driven backward, and downward; and the portions of the trachea, being ſeparated from their external proper orifices, are thrown away with the ſkin, which is then caſt off. By this motion, a cleft or opening is made in the back near the head, and through the aperture, the reſt of the body makes its way out; the ſkin being, by degrees, drawn back towards the fundament: This proceſs is aſſiſted greatly by a yellow kind of ichor, or fluid, which breaks forth from the cavities of the ſkull; and the Aurelia, or Nymph, appears then free and diſengaged.

“ Whilſt the inſect is making its paſſage out, the horns, or antennæ, which are thicker and more ſlimy than the reſt, are ſeparated from the Aurelia's body, and are torn, as it were, out of two cavities of the ſkull, beyond the place where they are inſerted; and their length, as they become unfolded, occupies the ſame place, which the two muſcles of the jaws formerly had. The wings alſo, and the legs appear to be circumſcribed in their limits; the wings are drawn from their ſituation near the fore-legs in the Silk-Worm; and the legs, from the lateral parts of the back, which were before of a purple colour. But as theſe unfolded parts are yet mucous, they eaſily ſtick to each other, and, inſenſibly growing dry, they become ſo cloſely united, that the Aurelia appears like one entire garment. Now, as theſe parts are peculiar to the Butterflies, and are deſtined for their uſe, the nature of the Butterflies ſeems to be, to emerge ſooner from the ſtate of the Worm, than is commonly believed, and to be earlier implanted in it; for evidently in the Silk-Worm, the beginnings of the wings, may be ſeen under the ſecond and third ring of the body, before the texture of the web. The antennæ, or horns, are likewiſe delineated on the ſkull; and the web being finiſhed, they have their own termination; nor will it be improper to doubt, that the new kind of life in the Aurelia, is only a maſk or veil of the Butterfly, which is already perfect within; intended that it ſhould not be ſtruck or deſtroyed by external injuries, but might grow ſtrong, and ripen, as a fœtus in the womb.” Thus far Malpighius, whoſe laſt-recited words anſwer to thoſe moſt evident experiments, which I have formerly exhibited to the noble Laurence Magallotti, when he was travelling through our part of the Netherlands, with his moſt ſerene highneſs the Grand Duke of Tuſcany, as I have before related. In this treatiſe I advance nothing particular concerning the Silk-Worm, except the figures of the brain, ſpinal marrow, and male organs of generation, which may be ſeen in Tab. XXVIII. fig. III.

Among the Butterflies which I have caught in the woods and fields, or on trees, flowers, and plants, and which I keep in my cabinet; there are ſeveral, which have been already deſcribed by Aldrovandus, Mouffet, Goedaert, and others: I ſhall therefore paſs theſe over, without enumerating their Caterpillars in this place. Among Caterpillars, ſome are hairy, others naked; ſome have tails; others have antennæ, or horns, ſpines, wreaths, ſpots, grooves, tubercles, tufts of hair, and, as it were, bruſhes; ſome are diſtinguiſhed by many, others with fewer colours; and a like difference is found in their feet. Some have heads like hogs, cats, and mice; others carry on them marks, as it were, of diſtinction; and ſome again are formed in different manners, and exhibit incomprehenſible repreſentations; ſo that they cannot be deſcribed by any detail of words; for which reaſon, Goedaert publiſhed them in their native colours.

In the mean time, whilſt we are conſidering the glittering beauty of the Butterflies, we cannot but declare, that the conſpicuous and beautiful tails of peacocks, and the ſhowy feathers of the Oſtrich, cannot be compared with the ornaments of theſe little creatures. Are not the wings of Butterflies moſt beautifully ſet, as it were, with pearls and diamonds, and with the turquoiſe, ſapphires, and rubies, which increaſe their ſplendor to ſuch a degree, that their baſe being made, as it were, of the ſubſtance of mother-of-pearl, and covered with plates of gold, ſilver, copper, or molten braſs, ſurpaſs the colours of the rainbow, by the bright reflexions of the rays? That theſe little creatures might be exalted to the utmoſt height of beauty, nature has favoured them with four wings, one of which beautifully repreſents the other, as it were, in a mirror or looking-glaſs; whereas they might have flown with only two, and that moſt ſwiftly, and have cut the air in infinite meanders, ſurpaſſing all imagination; as any one may ſee on opening the under pair of wings. Some of the Butterflies, which I preſerve in my cabinet, have oval, others round wings; ſome oblong, and ſome ſerrated; but, which is a very rare thing, one of them has wings on one ſide membranous, and on the other, only covered with the feathery or ſcaly duſt; ſo that they conſiſt partly of a bare membrane, and partly of one ſet with theſe feathers. I have likewiſe ſome, the lower wings of which terminate, as it were, in an acute tail; and in others they terminate in balls, or as if they had knobs on their tops: all theſe are diurnal. I proceed now to the nocturnal Butterflies.

In the next place then, we likewiſe refer to this order called the Aurelia, the nocturnal Butterflies, Phalænæ, or Moths. I preſerve, and can ſhew the curious, one hundred and ninety-three ſpecies of theſe creatures; of theſe, thirteen are very large; twenty-eight of a middle ſize; eighty-ſix ſmaller; and ſixty-ſix very minute. In this number there are thirty-five nocturnal, or night Butterflies; which, together with their reſpective Caterpillars, and their changes, have been deſcribed by Goedaert, and painted in their natural colours. I have likewiſe fifteen or ſixteen ſpecies of the Chryſallides; ſome of which are naked or ſmooth; others rough, having caſt the hairs of their outward ſkin; others are diſtinguiſhed with wreaths and various colours; others are colourleſs and naked; and others are, as it were, interwoven, and exhibiting a repreſentation through this web. I can likewiſe ſhew many of the eggs of theſe Butterflies; ſome of theſe are covered with hair; others ſurrounded with a kind of froth, and others again are hidden in other manners. I likewiſe preſerve ſome ſingular and very beautiful webs, nets and membranes, wherein they encloſe themſelves, with the greateſt circumſpection, and in a moſt wonderful manner, when they are about to change: it is, indeed, hard to comprehend, how theſe little creatures can confine themſelves in ſuch cloſe and narrow priſons; and can, though completed or folded up in theſe, perfect their webs *.

The induſtrious Goedaert has delineated fifty-ſeven ſpecies of Chryſallides; but I am ſorry to ſay, that among them all there is ſcarce one accurately repreſented, as I ſhall hereafter ſhew beyond a doubt. Indeed, a great many things occur, occaſionally, in the figures of Goedaert, which ſhould be corrected.

It is certainly worth obſervation, that, as well by the night as in the day, we obſerve innumerable living little creatures fluctuating in the air. This is not peculiar to the nocturnal Butterflies; for immenſe ſwarms of Beetles, and very many ſpecies of water inſects, betake themſelves to the air after ſun-ſet. 'Tis for this reaſon we obſerve flowers, trees, fields, and gardens frequented, night and day, by innumerable inſects, which ſeek for food upon them; that is, the great and ſupreme Creator, whoſe providential eye is always open on all created beings, appoints theſe creatures night for their day, and day for their time of reſt, ſince all things are at his pleaſure, and in his power. If at night you carry before you a lighted torch, you will entice towards you many ſpecies of ſuch inſects; and, when allured and deceived by the light, you may eaſily catch them.

Among the nocturnal Butterflies, which I preſerve, there is one, a Moth, the largeſt that has been taken in Holland. It is produced from a very deſtructive Caterpillar, with thin hair, which eats the bark, and even wood, of the Willow. This Caterpillar is called Spondyla rubra by Mouffet. I have ſometimes fed it for a whole year on white bread only. Mouffet relates, that the largeſt Moths kill with their wings, and afterwards devour, the ſmaller kinds: but this, I have found, is contradicted by experience; for the Moths are provided only with a hollow trunk for their mouth. To which may be added, that many of theſe inſects, as ſoon as they become fit for generation, entirely quit their former miſchievous diſpoſition, and, taking no food afterwards, apply themſelves only to propagating their ſpecies. Indeed, ſome do it more late, others earlier; according as their eggs become more or leſs mature, whilſt they lie in the habit of a Nymph, nay, and in the Caterpillar-form. Thoſe kinds muſt be excepted, which have the care of feeding their young; for it is abſolutely neceſſary, that ſuch ſhould be longer preſerved alive alſo by nature, for the ſake of their young. Thoſe which are not obliged to rear their young, as the Butterfly kind in general, we obſerve, die very ſoon after they are produced in their winged ſtate. So that hence we ſee, the whole change of theſe creatures is begun and finiſhed by nature, with regard to their generation only; as is more evident from thoſe ſingular obſervations I have made on Bees.

In the Ephemeri, nature has ordered the buſineſs of generation in a different manner; for, as ſhe has denied coition to theſe inſects, the females are obliged to caſt their ſeed into the water, in the ſame manner as fiſh caſt their ſpawn: this they do in the time when they beat and fly up and down on the ſurface of the water. On the other hand, the male Bees have air, inſtead of water, into which they diſcharge their ſperm.

I preſerve alſo that ſpecies of Butterflies, which the celebrated John Bauhinus has deſcribed in his treatiſe of hurtful winged animals, publiſhed in French in the year 1693. I have repreſented the Caterpillar of this ſpecies, the Chryſalis, and the Butterfly itſelf, in Tab. XXIX. Fig. I. II. and III. and have given it the name of Pernix.

I preſerve likewiſe various ſpecies of thoſe nocturnal Butterflies, known particularly by the name of Moths, becauſe they are produced from worms of the ſame name, that eat cloaths; and others that feed on paper, books, and duſt, as well as the leaves of trees. Among theſe worms there are ſome which, like Tortoiſes, carry their houſes about them: this will appear in our ſucceeding particular obſervations. Between theſe Moths and the other nocturnal Butterflies, which are called alſo by the ſame general name, there is this difference, that the

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* All that is required to produce the perfect Fly from the Chryſalis, is the evaporation of the abundant moiſture; and this will happen in a ſhorter time in hotter weather, and will require longer in cold Hence, the period of the ſame ſpecies lying in this ſtate, is varied by accidents; and that of different ſpecies, is alſo in its nature extremely various. Reamur has found, that eight days is ſufficient for ſome, and that others lie as many months.

former riſe immediately, and ſuddenly fly into the air; but the others, before they can fly away, make a noiſy and tremulous motion with their wings. This we obſerve alſo in other creatures, which, after they have reſted ſome time, are obliged thus to prepare themſelves for flight. I have given the true figure of the Tinea or Moth of cloaths, in Tab. XLV. fig. XXXI. to which is ſubjoined in fig. XXXIV. of the ſame Table, another kind of Moth, generated from a Worm that goes in its theca or caſe. And in Tab. XLIV. fig. XX. I have delineated a third Moth, produced from the leaf of an alder-tree. Finally, I have delineated the honey-comb Moth in Tab. XXVI. fig. II.

I can likewiſe ſhew in my collection that ſpecies of Butterfly, the male whereof is winged, but the female without wings: this privilege of the male is very ſingular and remarkable in this ſpecies. I have likewiſe obſerved, that the males of the Ants live free from labour, and have alſo four wings. Among the Bees the male has likewiſe this prerogative; it is diſcharged from all care of nouriſhing the young, and ſeems to be appointed by nature for generation only, not for nurſing: it is for this reaſon probably that this creature's life is ſo ſhort; and for the ſame cauſe we obſerve, that when the time of generation is over, theſe males are murdered by the working Bees. I preſerve two kinds of males and females of the Butterflies, juſt now mentioned; the former of which have larger eyes than the latter: this we likewiſe obſerve in Bees, Ants, the Ephemeri, and other inſects. The female of the Braſil Caterpillar that eats wood, is likewiſe without wings; this appears to me plainly, from its Chryſalis which I preſerve in my collection. I have likewiſe a ſecond ſpecies of Butterflies, whereof the male only is winged: It was taken in France; and I have repreſented it in Tab. XXXIII. fig. VIII.

I can in the next place ſhew ſome Butterflies, the wings of which are formed like feathers. Indeed we are to obſerve, that all the colours and different repreſentations, which conſtitute the ſplendid pride of the Butterfly's wings, conſiſt only of little feathers, differing among themſelves with inexpreſſible variety of conſtruction: this will be made manifeſt, when we ſhall treat of the manner, whereby thoſe wonderful protuberances of the wings are formed in the Butterflies, and, with many other curious incidents, ſhall explain that moſt delicate increaſe of the wings. Finally, I can likewiſe ſhew the ſmall Butterfly, which always flies in a ſtraight line, having an oblong tail for that purpoſe; and therefore it does not, like other kinds of Butterflies, deſcribe by its motion an oblique and unequal courſe in the air. Of this opinion is alſo the very learned Arnoldus Senguerdius, who, in his phyſical exerciſes, affirms, that the tail may have power to give an even, or uneven motion to thoſe creatures. We add here,

An example of the ſecond ſpecies or method of the third order of natural changes, which I call the Nymph-Chryſalis, or Aurelia, exhibited in that ſpecies of the nocturnal Butterfly, or Moth, whereof the male is winged.

TAB. XXXIII. No. I.

THE Caterpillar of this nocturnal Butterfly, or Moth, lying in its firſt coat or ſkin, which is called the egg-ſtate, and is repreſented to the life. The firſt figure exhibits the egg magnified.

No. II. The ſame egg, or rather the hard or indurated ſhell of that egg divided into two parts. A microſcopic delineation of this is again exhibited in the ſecond figure.

No. III. The Caterpillar of this Butterfly having attained its full ſize, it is very worthy of regard, on account of its wonderful form. Behind its head are ſeen, Tab. XXXIII. No. III. *a.* four bundles of hairs, like ſo many cloaths-bruſhes, clipped even at the tops: theſe are of a white colour inclining to yellow. In the fore part, near the head, are alſo two prominent bundles of hairs, which reſemble horns. Theſe are hairs, *bb.* of a black colour, and conſiſt of long, ragged, and uneven hairs; the tops whereof are adorned with a kind of branching feathers. On the two ſides of the breaſt are ſeen, *cc.* two other feather-like bundles of hairs, placed very beautifully like oars. Juſt before theſe are placed, *dd.* two ſuch other hairy oars; which, however, are much inferior in the beauty of their ſtructure, to the ſecond pair juſt now deſcribed, and are of a yellowiſh white, being almoſt of the ſame colour with the four former even-clipped bruſhes of the back. The whole ſkin of this Caterpillar is here and there beautifully variegated with fine colours, which are conſtituted, *ee.* by certain ſcaly and ſhort-haired little feathers, among which, the longer and looſe hairs are every where interſperſed; whilſt, in the mean time, the ſkin itſelf is obſerved to be of a bright red colour. At the hinder part of the body, this Caterpillar has a ſuperb feather-like tail, which reſembles the antennæ or horns of inſects, in form and colour. This creature has ſixteen feet; the ſix fore ones are placed near the head under the thorax; eight are placed under the middle of the body, and the other two at the end, juſt above the tail. Theſe Caterpillars are found plentifully in the gardens of Holland, living among the leaves of plum and cherry-trees, and in ſeveral other places.

No. IV. This figure exhibits the manner, wherein this Caterpillar has wound itſelf up, *aaa.* and ſettled itſelf quietly in its web. It begins in that to be ſomewhat immoveable about the thorax; and it is to be obſerved, that it there becomes alſo thick, and more extuberant; for the limbs, which have increaſed there under the common ſkin, ſwell by degrees. This is particularly manifeſt, *b.* about the third and fourth annular inciſion in the fore part near the head. Before this Caterpillar caſts its ſkin, it becomes wholly deprived of motion; and in the place juſt mentioned is ſtill more conſiderably diſtended; and the body becomes ſhorter, becauſe the blood and juices are conveyed toward the breaſt from the hinder parts. I here likewiſe ſhew the manner wherein this little creature, whilſt it twiſted itſelf continually up and down in perfecting its web, has by that continual agitation worn off the greateſt part of its hairy feathers; and as they have fallen into the cavity of the web, hence is produced a little feather-bed, as it were, in which the Caterpillar lies the ſofter. To this may be added, that theſe hairs, lying looſely and ſcattered in the web, render the change of the ſkin much eaſier, and they are afterwards moved backwards with the ſkins from the fore parts.

No. V. I exhibit in this figure the ſame Caterpillar, when upon caſting its ſkin, it has aſſumed the form of a male Chryſalis, and ſhews all the limbs of the nocturnal Butterfly, that is to burſt from thence.

This repreſentation is more obſcure in the Chryſalis than in the Nymph; for the latter, as has been before ſhewn at large, in its proper place, very clearly diſplays to the eye the limbs of the little inſect to be produced from it, on caſting its ſkin. However, as the Chryſalis does really alſo exhibit to view all the limbs and parts of the future creature, and is, in reality, that very creature which it repreſents, I ſhall likewiſe exhibit theſe parts in this Chryſalis. The fourth and fifth figure anſwer this purpoſe.

No. VI. In this figure I repreſent the ſame Caterpillar, as it appears when firſt changed into a Chryſalis, and afterwards, after caſting its laſt ſkin, becomes a male nocturnal Butterfly or Moth. When theſe inſects have obtained this laſt form, they afterwards neither grow nor are at all changed, but are intent upon generation only; as I ſhall more clearly ſhew in the explanation of the following figures. In the mean time I ſhew the elegant antennæ, *aa.* which this male has, its ſmall body, *b.* and its four wings, *cc.* which the female has not.

TAB. XXXIII. FIG. I.

The egg of the nocturnal Butterfly, whereof we are ſpeaking, is the principal figure repreſented magnified: Its purple ring, and ſome little depreſſions and inequalities, whereby it is remarkably diſtinguiſhed from all other eggs, are ſhewn in this figure. This egg is alſo ſomewhat depreſſed in the middle, which makes it appear as if perforated and open in that part, when viewed without a microſcope.

FIG. II.

This exhibits the ſame egg broken into two parts, and forſaken by its inhabitant: for as it is covered with a hard ſkin, or ſhell, like a hen's egg; hence it is not rolled up, or drawn aſunder like a membranaceous integument, as is commonly the caſe in the eggs of Ants and Bees: it is on the contrary torn from the Caterpillar, which it before inveſted, in form of a jagged ſhell. This manner of ſeparation is not univerſal among all theſe eggs; for, according as the ſkin or ſhell is more or leſs hard, and the oppoſition great or ſmall; the deſerted ſhells are found to vary more or leſs from the form we have deſcribed. One may from thence ſee, after what various ways the inſects put off their firſt coats and ſkins, which may be eaſily illuſtrated by other examples.

FIG. III.

In the third figure I ſhew the method wherein theſe eggs are glued to the web. I ſhall preſently treat of this particular more at large. It is in this deſerted web ſeen alſo, what an hole the nocturnal Butterfly made, when about to creep out of the web.

FIG. IV.

In the fourth figure are repreſented all the parts of the male Butterfly in the Chryſalis itſelf; namely,

a. The two eyes in the head, under which, in the thorax, next between the upper legs, the trunk is ſituated.

bb. The antennæ or horns, with their integuments, removed from their natural ſituation, which is cloſe to the body.

cc. Six legs likewiſe removed from their places.

dd. The upper and under wings in their natural ſituation.

e. The rings of the body, in which are repreſented ſome hairs deprived of their ſkin: This is likewiſe the caſe, with reſpect to thoſe hairs which are ſeen on the head.

FIG. V.

All the before-mentioned parts are in this figure exhibited in the Chryſalis of the female Butterfly of this ſpecies; but theſe are not removed out of their natural ſituation. It is evident, by this figure, that the female Chryſalis differs in three reſpects from the male Chryſalis: firſt, as to the horns or antennæ; then in reſpect to the wings; thirdly, in regard to the ſize and thickneſs of the body; but theſe things will be made more evident, in the explanation of the ſixth figure. I muſt alſo call to mind here, that this compoſition or texture of the limbs, though various in the ſexes, yet never makes what is called, an eſſential difference between the Chryſallides of the various inſects, but only an accidental one, conſiſting in the ſhortneſs or length, or bigneſs and ſmallneſs of the parts. We muſt further obſerve, that this Chryſalis, and the inſect, which, upon changing its ſkin, is to ariſe out of it, do not in the leaſt differ from each other, except only in the order and diſpoſition of the parts, which are arranged in the Chryſalis, ſomewhat otherwiſe than they are in the perfect inſect, or the Chryſalis, after caſting its ſkin: This ſhould indeed be obſerved moſt carefully.

Fig. vi.

After delineating, under No. VI. the male Butterfly, together with its moſt elegant horns, its fine and ſlender body, and four expanded wings; I exhibit under the ſame No. VI. all theſe parts, but much more imperfect; viz.

aa. Two uncouth horns or antennæ.

b. A thick and diſtended body.

cc. Four ſhort wings, or rather only rude portraitures of wings.

Hence it is evident, that it may be truly ſaid that this female has no wings. We may, for this reaſon, ſee all its ſix legs without any impediment; though in the male they lie ſo far under the wings, that only the two fore ones are occaſionally ſeen between the horns and ſuperior wings; as is manifeſt under N°. VI.

In reſpect therefore to this ſpecies of inſects, it deſerves notice in what a wonderful manner the adorable Creator has eſtabliſhed diſtinctions between the males and females; and what noble prerogatives he has given to one, and denied to the other, of them. Whilſt beautiful antennæ, an agile and light body, and very ſwift flying wings, raiſe the male to the thrones and ſceptres, as it were, of kings; the female, being deprived of all thoſe remarkable privileges, and ſcarce able to bear the load of a ſwollen, tumid, and thick body, ſeems to be condemned by the moſt wiſe Nature, who has given ſovereignty and dignity to the male only, to keep her neſt perpetually, and take care of domeſtic affairs. Hence it likewiſe is, that this female, like a moſt prudent houſewiſe, never goes out of her habitation; but is always fixing the fruits of her matrimony, that is, her eggs, to the ſurface of the web out of which ſhe herſelf crept; as may be ſeen in Fig. iii. Indeed, this cuſtom of faſtening the eggs to the web in a conſtant method, and, by the immutable law of nature, is ſo peculiar to this ſpecies of inſects, that I have never hitherto obſerved it in any other kind whatſoever. This female, therefore, affords a beautiful inſtance of induſtrious houſewifery; and, therefore, ſhe deſerves to be dignified with that name. The male, in due time, reviſiting his female, and paying her the proper tribute of benevolence, ſhews, in his ſpecies, that he never deviates from the character of a chaſte and honeſt husband; ſince he gives the aſſiſtance of his excellence and dignity to the female, and ſupports her weakneſs *.

Fig. vii.

The female is here repreſented, according to nature, ſo full of eggs, that her whole belly is diſtended with them; and as the integuments of this part is very thin, the eggs are diſtinctly viſible through it. Nay, it is likewiſe ſeen how the ſkin turns and inſinuates itſelf round the convex windings of the eggs, and runs into the little ſpaces between them; ſo that it is like a cluſter of grapes. In order to produce theſe eggs very clearly to view, the ſkin needs only (Tab. XXXIII. Fig. vii. *a.*) be diſſected in the belly and back, and raiſed from the body towards the hinder parts; for then one may diſtinctly ſee after what manner they are placed within. Theſe eggs are found to be of a round figure, when taken out of the body; and have on the upper part, as I have already obſerved, a purple ring: but, on the lower part, they are of a white glittering hue, like pearls. Their ſhell or ſkin is ſo hard, that when they are dried in the air, they are not liable to break; and, therefore, the natural preſerved ſpecimens of them will be always agreeable to the perſon who ſees them.

It is very remarkable in this creature, that, when it is yet in the condition of a Caterpillar, one may, even then, manifeſtly ſee in it the rudiments of eggs. Theſe, when the Caterpillar is changed into a Chryſalis, ſhew themſelves much more diſtinctly, and, having acquired their utmoſt perfection, are at length ſeen thus elegantly in the Butterfly itſelf; that is, they ſeem watery in the Caterpillar: they appear in the Chryſalis, as it were, membranaceous and flexible; but in the inſect itſelf they are hard, and reſemble a real ſhell, very little different from that of hen's eggs; and, for this reaſon alſo, they will crack and break like an earthen veſſel. From hence appears the reaſon, why theſe eggs retain their figure, when dried; for this is the caſe, with reſpect to all eggs that have a hard ſhell: whereas the contrary obtains, in all thoſe that have a thin and tender ſkin; as may be ſeen in the eggs of Bees, and many other inſects, which are almoſt entirely deſtroyed by drying them.

Before I conclude this hiſtory, it may be neceſſary to add ſomething more concerning the parts of the Aurelia, that theſe may be the more appoſitely compared with the parts of the Nymphs, and the difference between them underſtood. When theſe and other Caterpillars are caſting their ſkin, and preſenting their before hidden parts to outward view, in the beginning of this change we obſerve them ſoft, tender, and ſomewhat moiſt; and this is the caſe likewiſe about the parts of the Nymphs themſelves. But, a little after theſe ſeveral parts in the Chryſallides approach toward each other, they are then joined together; and indeed ſo cloſely, evenly, and equally united, that they repreſent, as it were, a continuous, ſmooth, undivided, and varniſhed ſkin. This is by no means the caſe in the parts of Nymphs: for they are not at all joined; but are only diſpoſed near each other in ſuch a manner, that one may diſtinctly ſee each of them. This is the true difference between the parts of the Nymph and thoſe of the Chryſalis.

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* The progeny of the ſame ſpecies of Butterfly may, under favourable circumſtances, be hatched at two ſeaſons of the year; and conſequently two generations, inſtead of one, may be produced in one year. Reaumur has obſerved, that the eggs of the Butterfly, which would be hatched in a few days if laid in ſummer, will, if depoſited in autumn, lie till the winter; and, unleſs the cold have been ſevere, hatch the following ſpring. The Butterflies produced in about ſix weeks from the Caterpillars of theſe eggs, will lay their eggs in ſo warm a ſeaſon, that they will hatch, and paſs through all their changes into Butterflies the ſame year.

The reaſon why the limbs in the Chryſalis unite, and are, as it were, glued and faſtened together, is, becauſe the ſkin, inveſting the Chryſalis in that part where the union or junction is made, is conſiderably thinner than where it is expoſed to the air. And therefore, on account of this inequality of the ſkin, it was abſolutely neceſſary to preſerve all the members from the drying air, and to defend them from injuries by their mutual compactneſs.

Theſe things are circumſtanced in the parts of the Nymphs in a contrary manner; for their ſkin is found to be equally thick in all the parts, ſo that it would be ſuperfluous to unite them together. But, even in Nymphs, ſome parts ſometimes occur, which are covered with an equal ſkin. This holds chiefly when ſome parts reſt upon or are ſupported by others; and it is obſerved principally about the caſes of the wings, which have a much thinner ſkin, where they receive the wings, than where they are turned to the air: therefore, in this reſpect, they entirely agree with the Chryſallides.

It certainly deſerves great notice, how delicate and thin the integuments of thoſe parts are, where they are found to lie on each other: and hence even the continued ſkin, which covers or incloſes theſe parts, has its external part thick, and is ſtrong and hard; but in the internal part it is thin, tender, ſoft, and formed like a ſpider's web. This ſkin ſometimes alſo is ſo fine, that the rays of the ſun exhibit therein various colours to the eye, eſpecially where it is in any degree folded: as is obſerved in very thin and fine blown glaſs, and in the ſlender filaments of a ſpider's web.

This being well conſidered, it is eaſy to underſtand why many Butterflies are produced deformed; that is, when their limbs, under the period of the transformation, are not well united together, as frequently happens. Indeed I have, more than once, ſeen that they have dried and periſhed, by reaſon of this defect of a proper union. The ſame effect may be performed by art, and a certain operation: I mean, we may thus produce Butterflies that are deformed. I can alſo very eaſily diſunite all the limbs of the Chryſallides; for, naturally, theſe parts in the Chryſallides will then never ſeparate themſelves further, not even at the time they are ſtripped of their ſkin: for the ſkins to be cut off from thence, have only three or four cracks or openings, ſince the thinner ſides of theſe inveſting parts are then very eaſily broken further, with the leaſt motion; ſo that there will be no need to move the reſpective limbs out of their places.

As thoſe who ſearch into the ſecrets of nature have not obſerved this, I am therefore inclined to think they have imagined, in conſequence of this overſight, that the continued ſkin of the Aurelia conſiſted of a texture of the parts united one with another. They have therefore fancied, that the inſect lies in that uniform and undivided ſkin, in the ſame manner as the chicken lies in its undivided ſhell. But this is contrary to all truth; for every part of the Chryſalis, as well as the limbs of the Nymph, is inveſted with its reſpective integument. And this is the more inconteſtably certain, becauſe theſe limbs, together with the ſkin wherewith they are ſurrounded, are found entirely perfect in the Worms and Caterpillars, and may be even there ſeparated or diſengaged; ſo that one of theſe inſects is, in reality, always in another: as I ſhall hereafter deſcribe, and abſolutely prove.

Another remarkable thing in theſe Aureliæ, whereof we are ſpeaking, is, that even the hairs of the Caterpillar caſt a ſkin, and are afterwards ſeen in the Chryſalis. And hence ariſes another invincible argument, moſt clearly demonſtrating, that the Aurelia is not a creature newly transformed, but is really the former creature, which has caſt its ſkin. The whole change, or rather accretion of the parts and limbs, conſiſts indeed only in this, that the inveſting membranes or ſkins, which are ſo many veils that obſtruct the ſight, are removed by degrees, and thrown off; ſo that the limbs, which, from the firſt, lay hidden in the inſide, are, in the end, ſeen on the outſide. In all theſe changes, nothing is more wonderful than the motion by which alone they are ſeverally produced, and perfected by means too difficult to be inveſtigated. The deeper we here look into nature, the more we are obliged to confeſs our blindneſs, and our ignorance. Indeed, there is nothing more true, than that all theſe things, which I advance and publiſh, are no more than the naked ſhadows of the inexplicable myſteries of the Great Creator: the internal nature, and true diſpoſition, of theſe meanders are above the reach of our limited underſtandings.

I ſhould never conclude, if I attempted to proſecute minutely all the wonderful things that occur in theſe Chryſallides: and, indeed, I ſhould weary out the reader's patience by a prolix recital of them; ſince he muſt firſt have ſome knowledge of the hiſtory of theſe inſects, who would properly underſtand what is delivered. I ſhall add but one thing more concerning the eggs of theſe inſects: this is, that as the rudiments of theſe eggs may be perfectly ſeen in the Caterpillar, there ariſes from thence a ſtill more powerful argument to prove, that there is no real metamorphoſis or change, or real transformation of parts in the creature; but only a ſimple growth, or accretion, as in all other animals; only, that it is more conſiderable, and more admirable, than in the other creatures. I ſhall alſo add, that the egg itſelf is, in reality, no other than a little inſect, the ſtrength of which, by degrees, increaſes in its ſkin or coat; until it has at laſt acquired ſufficient ſtrength to break through this ſkin or ſhell, and caſt off its firſt integument. It is therefore, from what has been ſaid, clearer than the meridian ſun, of what infinite uſe ſuch experiments are to us; as thoſe I have propoſed, by way of ſpecimen, at the end of the third chapter.

In the webs, which Caterpillars form, there is obſerved a wonderful variety; for as they ſerve them in the place of neſts, every Caterpillar, according to its peculiar nature and diſpoſition, forms and perfects its web its own way. Though theſe webs are conſtructed with wonderful art, yet thoſe Caterpillars, which are encloſed in no web, excel all others in art and invention. Some of theſe, which bury themſelves under the earth, are inſtructed to make caverns or holes in it ſo artfully, that they ſeem to have a more ſecure habitation there, than others in their walls. Some others, that remain above the earth, have the art to fix their webs with ſuch ſtupendous dexterity to plants, trees, walls, and in hedges, that they ſafely hang with it, though expoſed every way to the ſurrounding air; and are at length changed, after caſting their ſkin, into very beautiful Butterflies. It is moſt wonderful, that theſe little creatures, at the time of their change, know how to diſengage their claws from the web, and to change the ſkin of theſe their ſmalleſt parts, together with the ſeparating exuviæ; whilſt, at the ſame time, they remain fixed by thoſe claws in the web. Indeed, in this art, the Caterpillars by far excel the moſt active of the human ſpecies in their geſticulations. I have likewiſe ſeen ſome Caterpillars, which knew how to bite off a certain part of the leaves of trees; and, as in a ſafe habitation, afterwards have encloſed themſelves therein, by the help of the threads they have ſpun. Others weave oval neſts; others exactly round ones; others oblong ones; others make them channelled; others ſuch as are like a delicate network; others angulated; ſome weave into their work wood, ſand, ſhells, ſtones, and other matters: others ſimply, tho' very artfully, roll themſelves up in the leaves of plants and trees. In a word, the wonderful ingenuity of Caterpillars is manifeſted in a thouſand inventions; and in all of them the hand of the Great Creator is moſt clearly ſeen, who has infuſed ſo much prudence, as it were, and wiſdom into thoſe creatures, exhibited in order, weight, and meaſure.

I have particularly treated of the Butterflies hitherto deſcribed in the third chapter of this work; and I have ſhewn there, that the induſtrious Goedaert, in Part I. Obſ. 59, and Part II. Obſ. 30, has given a ſhort deſcription of them, and exhibited their figures; though he did not perfectly know theſe creatures, nor could diſtinguiſh the male from the female.

Fig. VIII.

I have found theſe creatures, here treated of, not only in our part of the Netherlands, but alſo in France; but they were of a different ſpecies. This will appear by the eighth figure, wherein I repreſent theſe inſects in the act of coition. The female of this ſpecies is abſolutely without wings, (Tab. XXXIII. Fig. VIII. *a*.) and has two ſhort horns, ſix legs, and a body divided into ſeveral rings. The male, on the contrary, is exhibited with two beautiful horns and four wings, *b*. and with a body ſomewhat larger than that of the Holland Butterfly, delineated under N°. VI. Theſe were alſo nocturnal Butterflies; but their bodies were more ſwollen than thoſe of Holland; the male whereof is diſtinguiſhed for its ſmaller body and ſmoother wings. Theſe French Butterflies are variegated with a gray and blackiſh colour, mixed with white. This mixture renders them very beautiful. The diviſions of the back are tinged with a browner black; and there are, moreover, obſerved ſome yellowiſh rings in that part, conſiſting of hairs. From what Caterpillars theſe Butterflies are produced, I do not know. I found them in a field in the act of coition; ſo that, from thence, I could affirm for certain, that the male and female are the two ſexes of the ſame ſpecies.

The remarkable neſt, which I have delineated in the hiſtory of the Ephemerus; firſt publiſhed ſeparately, and which I proved at the ſame time to be conſtructed of ſmall bitten pieces of wood, laid together, and joined like the beams of houſes in Ruſſia; this neſt, I ſay, is built by the wood-eating Caterpillar, which inhabits it, and carries it about on its back in form of a pyramid. Theſe Caterpillars are likewiſe changed into a winged male, and a female without wings. This appeared very evidently to me, when, upon opening the neſt, I found the Chryſalis of the female and the Exuviæ of the Caterpillar in it. Therefore, ſeveral pairs of little creatures ſeem to exiſt in nature; the males of which have this peculiar privilege above the females. It likewiſe appears from thence, how much the inſects of one and the ſame ſpecies may differ from each other. Perhaps the ſame thing likewiſe holds in ſome quadrupedes, birds, or fiſhes; particularly in thoſe ſpecies, the males or females whereof we have not yet been able to diſtinguiſh. Some ſay, the Snake has no difference of ſex, which others again deny. I cannot preſume to decide this controverſy, as I never took any particular pains about that ſubject.

The anatomy of the common diurnal and variegated Butterfly.

THE INTRODUCTION.

THE hiſtory I am about to give, under the ſecond mode of the third claſs or order of natural changes, is ſo amazing in all its circumſtances, that it might very well paſs for a romance, were it not built upon the moſt firm foundations of truth. Facts alone ſupport it; ſo that, how much ſoever our comprehenſion may fall ſhort of the things to be related, we muſt aſſent to them notwithſtanding; and we ſhould ſtudy them alſo, as ſome of the moſt ſhining miracles of God's power and goodneſs.

In this hiſtory we ſhall ſee moſt ſurpriſing changes in the limbs of theſe inſects, growing under one another, that anatomy has ever diſcovered; ſuch changes, indeed, as no human wit could contrive, or could even think of, had not God, the great Author of theſe wonders, been graciouſly pleaſed to reward our induſtry with the diſcloſure of them. In this hiſtory we ſhall behold a poor and wretched inſect loſe by degrees all motion, and, in appearance, ſtand conſigned to death and the grave; in which ſeemingly hopeleſs condition, however, all its former limbs acquire an extraordinary degree of perfection, till, at laſt, riſing from the ſepulchre in all the gaiety and magnificence of the richeſt ornaments, and moſt reſplendent colours, it no longer continues a reptile, creeping upon the earth; but, ſoaring into the air, changes its ſlow and heavy pace into the moſt nimble and unreſtrained flights.

This creature, in its painful and humble ſtate of life, ſupports itſelf with crude and undigeſted food; and, ordinary as this refreſhment is, the inſect is obliged to earn it with much labour and danger: but when freed from the jaws of death, and after paſſing through a ſecond infancy, the pureſt nectar becomes its portion, and the air its element. It raiſes itſelf boldly toward the ſkies, and roves at pleaſure from meadow to meadow, and enjoys, without care or concern, the exquiſite juices which bounteous nature has prepared for its uſe, and preſents it from the unſullied cups of the moſt fragrant and beautiful flowers.

It has now put off its old body; and the entrails, which were before ſupplied with coarſe food by the painful operation of the teeth, and which digeſted this food by a violent trituration of the ſtomach, are become more tender, delicate, and fine, ſo as only to ſuit a more pure and elegant aliment: and often the happy creature is enabled to live ſeveral months ſucceſſively, without the leaſt want of nouriſhment.

To ſum up all theſe wonders in a few words, the creature, that heretofore crept upon the earth, now flies freely through the air; ſips its food, inſtead of chewing it; and, far from creating our averſion by its frightful prickles, and foul appearance, it attracts our admiration by the moſt elegant ſhape and cloathing; and from being ſcarce able to move upon the humbleſt ſhrubs, acquires ſtrength and agility to tour in its lofty progreſſes, far above the talleſt inhabitants of the foreſt.

All theſe ſurpriſing, and indeed almoſt incomprehenſible changes, from indigence to affluence, from contempt to glory, from labour to eaſe, will be amply deſcribed in the following hiſtory, and every one may eaſily underſtand how they can happen, and are actually effected.

By comparing theſe ſtrange viciſſitudes with the wretchedneſs of our own preſent life, our death, and reſurrection; and examining likewiſe the cauſes of our miſery, and the beſt methods of ſubduing, and even eradicating in ourſelves, the latent ſeeds of decay and deſtruction, in order to prepare our ſouls and bodies for a glorious reſurrection; we ſhall, beſides the moſt innocent and becoming pleaſure, reap very conſiderable and laſting advantages, by being powerfully excited to praiſe God, without intermiſſion, as he deſerves, from theſe ſurpriſing effects of his wiſdom and power, now clearly laid open to our inſpection.

CHAP. I.

A deſcription of the external parts of the Caterpillar, and a diſſection of the internal, ſo as to give a ſatisfactory account of the blood, muſcles, kidney-ſhaped parts, ſtomach, gullet, inteſtina cœca, or cloſed guts, ſilk-bags, fat, pulmonary tubes, heart, brain, and nerves.

THERE are a great number of Caterpillars that become, after their change, diurnal or day Butterflies, that are found feeding on nettles, with which they ſupport themſelves; ſometimes devouring that plant to ſuch a degree, as to leave nothing but the ſtalk remaining. It is of theſe I intend to ſpeak in this place. They are very common in Holland, during the ſummer months. The ſkin of this inſect appears thick ſet with very ſharp prickles, Tab. XXXIV. Fig. I. *a.* At its full growth, it is almoſt an inch and a half long. It is of a deep brown colour, except on its ſides, which are of a yellowiſh green, ſomething inclining to white. Theſe Caterpillars differ ſo much from each other in this reſpect, that, in point of colour, it is impoſſible to deſcribe them diſtinctly. This little inſect has ſix legs on that part of the body which is next its head: of theſe legs, I have here delineated only the three that belong to one ſide, *b.* The middle part of the body is furniſhed with eight legs more, four on each ſide, *c*; beſides which there are two others that ſpring from the diviſion forming the tail, *d.* That the conſtruction of this Caterpillar may be the more perfectly underſtood, I ſhall repreſent it as it appears, ſomewhat magnified by a microſcope. Thus we ſhall ſee, that, counting the head a tail, it is compoſed of thirteen annular diviſions, Fig. II. 1, 2, 3, 4, &c. The head is of a horny ſubſtance, or like bone, and of a ſhining black colour; and, here and there, it is covered with a kind of hair like briſtles. On each ſide of the head are ſix black eyes, *aa*, and under the eyes the antennæ, *bb.* There is a lip on the lower part of the diviſion which conſtitutes the head, and under and near the lip are placed the teeth, *cc.* Near the teeth are three little protuberant ſpots, the middlemoſt of which is a nipple, or papilla, *d*, from which the Caterpillar emits a kind of thread; which will be hereafter conſidered.

There are ſome briſtly hairs on the ſecond ring, and under theſe hairs is a black ſpot, above the firſt pair of legs. This is the firſt of the puncta reſpiratoria, or points of reſpiration, by which the inſect breathes. The legs, *e.* conſiſt of various joints, compoſed of a bony or horny ſubſtance; and each is terminated by a claw of the ſame ſubſtance, and of a deep red colour. There are no openings for reſpiration on the third and fourth rings, as well becauſe the wings of the future Butterfly lie againſt thoſe rings under the Caterpillar's ſkin, as becauſe ſuch breathing-holes would greatly obſtruct the motion of the limbs. The third ring has on each ſide two ſharp and briſtly hairs, which, at ſome diſtance from their roots, produce many others. The two lower of the original hairs, which are likewiſe the leaſt, are of a white, and the two upper ones of a black, colour.

The fourth ring is of the ſame form with the third; but as I have repreſented it a little ſideways, there appears on it only one pair of briſtles. The legs, Tab. XXXIV. Fig. II. *fg*, placed on both theſe rings, reſemble exactly thoſe of the ſecond ring. Between the hairs already mentioned, there are others, which I have been obliged to omit in the figure I have given, for fear of rendering it confuſed. Theſe laſt hairs are white, and they ſpring from whitiſh ſpots in the center of a black ground.

On each ſide of the fifth ring there are three briſtly hairs, with one exactly on the middle of the inſect's back, *h.* The firſt and largeſt pair of theſe hairs, *i*, lies a little ſlanting, on account of the ſingle hair on the middle of the back. The ſecond pair, or that next to the firſt, riſes over the points of reſpiration; and the third pair, *k*, under thoſe points, on the declivity of the belly. I have, to avoid confuſion, omitted the lateral prickles; but have repreſented the others juſt as they appear, covering almoſt every ring of the body. The rings that follow, all to the thirteenth, are exactly of the ſame form, with breathing-holes in every one of them; ſo that the inſect has no leſs than eighteen of theſe openings diſpoſed along its ſides, with a blackiſh edge or border to every hole.

The fifth and ſixth rings have no legs annexed to them; but the ſeventh, eighth, ninth, and tenth have each a pair, ſpringing from the lower part or belly of the inſect. Theſe legs are covered with a fine membrane, conſiſting of many joints, and are armed with little red claws, *llll*, ſet round the extremities of their legs.

The eleventh and twelfth rings are likewiſe without legs. The only pair, in this part of the inſect, ſprings from under the tail, *mm.* The ring, conſtituting this part, has but one pair of ſharp hairs.

The anatomy of the Caterpillar.

HAVING thus ſuccinctly deſcribed the external conſtruction of this Caterpillar, I am now to exhibit and demonſtrate its internal parts. The firſt thing that preſents itſelf, on opening the back of this inſect, is the blood, which flows freely from it. This is of a tranſparent green, and may be made uſe of as a paint for that purpoſe; though, as it dries by being expoſed to the air, it loſes much of its original luſtre, and by degrees turns yellowiſh. There next appear, immediately under the ſkin, the muſcular fibres, which ſerve to move the rings of the body. On raiſing of theſe fibres, the fat appears, as likewiſe the heart, known by its panting motion: this I ſhall preſently deſcribe. On the hinder part, upon the back, and between the laſt rings of the body, there are two ſpots or particles, with ſome diviſions in them, Tab. XXXIV. Fig. III. not unlike the kidneys of men or quadrupedes. On opening theſe ſpots, they are found to contain ſome veſſels, and to have a connexion with the lower rings, by means of ſome ſlender filaments, and certain pulmonary tubes. In my opinion, theſe particles do not attain their full growth and perfection, till the inſect becomes a Butterfly. This appears plainly enough in Silkworms, whoſe teſticles ſpring from this part. I ſhall therefore reſerve what more I have to ſay, on this ſubject, for my deſcription of the Butterfly, as they appear only in an embryo-ſtate in the Caterpillar.

Removing the parts already mentioned, we come at the ſtomach. This almoſt entirely fills the Caterpillar's body; and, though it be ſo very capacious, is always as full as it can hold, the inſect being extremely voracious, ſo that it hardly ever deſiſts from eating a ſingle moment. During this part of its life, it ſeems entirely confined to the two operations of taking in its food, and diſcharging its excrements; by which means it acquires its proper ſize in a few days. The gullet, Fig. IV. *a*, is a ſmall and ſlender tube, which running from the forepart of the ſtomach to the mouth, through a ſlit in the ſpinal marrow, juſt under the brain, and growing larger and larger in its progreſs, it forms a communication, for the inſect's food, between the mouth and ſtomach. I have repreſented only a few of the pulmonary tubes, *b b b b*, in the forepart of the ſtomach, where they appear like ſo many veſſels, elegantly diſperſed over its ſurface, and ſupply it with the vital air from every ſide. Amongſt theſe tubes is to be ſeen a tendinous ligament, *c c*, which runs, both above and below, from one end of the ſtomach to the other. It ariſes from the tendons of the muſcular fibres belonging to this part. Theſe muſcular fibres are ſeen diſtinctly through, and I have repreſented them on each ſide of the ſtomach, *d d d*; but, to avoid confuſion, I have been obliged to leave out the pulmonary tubes, that are to be ſeen in the inſect in the ſame place. The ſtomach conſiſts of three coats. The outward coat, upon which the pulmonary tubes are diſtributed, is very thin: the next is thicker, and muſcular; the third, which immediately contains the ſubſtance that is to be digeſted, is very delicate like the firſt.

On the upper and lower parts of the ſtomach are placed ſix cloſed guts, which, deſcending towards the thick gut, there terminates in little tubes, that have no paſſage. Theſe ſix little guts, which are here repreſented out of their natural ſituation, by returning upon themſelves, and running back towards their origin, form, as it were, twelve inteſtines; ſo that, on parting them from the ſtomach, and diſpoſing them orderly along its ſides, there appear ſix on each part. Theſe little guts ariſe on each ſide, from a trunk, in form of a knot, Tab. XXXIV. Fig. IV. *f f*, which ſprings from the inteſtine that immediately ſucceeds the ſtomach; and then again, being divided into ſix tubules, theſe run back towards the thick inteſtines, *g g*, againſt which they are folded and curled in a moſt ſurpriſing manner, *h h*. One of the thick inteſtines, *i*, in which the excrements are reduced to form, is here repreſented alſo; and this thick inteſtine ends in the rectum, or ſtraight gut, *k*.

On removing the ſtomach, there appear very plainly two little canals, Fig. V. *a a*, which before had ſeveral windings, and lay againſt the ſides of the ſtomach. Theſe canals aſcend to the forepart of the head, where I traced them very high, as far as the brain; but could follow them no further, ſo that I cannot aſſign their abſolute origin. On the forepart they are very fine and ſlender, *b*; but afterwards dilate greatly, *c*, till at laſt they terminate in two ſharp filaments, *d*, which have their inſertion near the cœca, or cloſed inteſtines.

It is no eaſy thing to determine the uſe of theſe little parts from the diſſection of the Caterpillar: to pretend to gueſs at it, would be folly. Our buſineſs is to find out the intentions and operations of nature, not to contrive them. At firſt, I took theſe for the ſilk-bags of the Caterpillar, on account of their great reſemblance to thoſe of the Silkworm. But I was afterwards convinced of my miſtake, by finding them unaltered in a Caterpillar, that had made its web. This circumſtance may ſerve to convince us, that they muſt be of ſome uſe to the future Butterfly.

The real ſilk-bags of the Caterpillar are not more than one fourth part ſo large as the veſſels, which at firſt paſſed upon me for ſuch; for the Caterpillar ſpins but very little; and I have therefore omitted, as not much worth notice, the repoſitories of the matter with which nature has ſupplied her for that purpoſe.

After the foregoing parts have been examined, the fat becomes conſpicuous. This ſubſtance, in a manner, takes up all the inſide of the Caterpillar, not filled by the ſtomach, the head and tail not excepted. It is of a yellowiſh colour; but here and there inclines to white. As to its form, it looks like a congeries of little membranes, folded one over the other; but differing greatly in conſtruction and texture. The fat ſerves to this amongſt other purpoſes, that it binds and ſupports the pulmonary tubes, which are diſtributed through it in great numbers.

The pulmonary tubes ariſe from three remarkable pairs of branches, which are ſeen on each ſide in the breaſt, belly, and tail of the Caterpillar; and the pulmonary tubes, propagated from every part of theſe branches, communicate with each other at every one of the points of reſpiration. In theſe parts alſo are to be ſeen a great many ramifications of pulmonary tubes, which ſpread themſelves all over the body, ſo that no part of it can be aſſigned, not even any of its horny ſubſtance, that is not furniſhed with its pulmonary tubes.

The beſt way to ſee the heart, Tab. XXXIV. Fig. VI. *a a*, of the Caterpillar, is by laying it on its back, and then opening the belly. It is then found, that this organ extends from one end of the body to the other. It pervades the tail, belly, and breaſt; and thence ſtretches very high up to the brain itſelf. This heart is an oblong, delicate, and ſlender little tube, which widens in ſome places, and again grows narrower in others. It is furniſhed with ſome pulmonary tubes, and with ſome muſcular and fibrous hairs, which run part lengthways, and part croſſways, and require a great deal of art and induſtry to diſcover them. This tube contracts itſelf by the help of its own fibres, and is dilated again by the joint efforts of a prodigious number of muſcles, *b b b b b b*, of a ſingular form, which grow on its outſide; and, though eaſily ſeparated and diſtinguiſhed from one another, they look, at firſt ſight, as if they were but one continued muſcle. The deſign I have given, to illuſtrate the deſcription of this organ, repreſents only a part of it.

It is no eaſy taſk to get a ſight of the brain and ſpinal marrow in healthy Caterpillars, on account of the great quantity of fat that involves theſe parts; ſo that ſickly inſects, or thoſe which have been otherwiſe waſting for ſome days, with conſtant labour, are the fitteſt for this purpoſe. The inciſion muſt be made in the back, as the brain and ſpinal marrow lie in the abdomen. The brain is compoſed of two hemiſpherical lobes, Fig. VII. *a*, placed juſt over the inſertion of the gullet into the mouth; and under theſe lobes are to be ſeen the heads of the ſpinal marrow, compoſed of two nerves, *b b*, which unite at ſome diſtance, and form the firſt knot or joint, *c*, from whence nerves are diſtributed to the muſcular parts of the head. The marrow then parts again into two branches; and the nerves, *d d*, ſpringing from thoſe branches, are diſtributed amongſt the muſcles of the neck. Another conjunction of the main nerves forms the ſecond little knot or joint, *e*, which is ſomewhat leſs than the firſt. From this ſecond knot or joint iſſue two branches, as from the firſt; and theſe branches unite again, to form the third joint or knot, whoſe ramifications are diſperſed amongſt the muſcles of the thorax. Here the marrow divides itſelf again for the third time, and runs in this divided form a conſiderable length, *f*, before it coaleſces into the fourth knot or joint, *g*; to which ſucceeds, after a ſhorter ſeparation, the fifth, *h*. Theſe laſt joints or knots ſupply with nerves the muſcular parts of the embryo legs and wings of the future Butterfly. After this, the marrow parts no more; but it has however ſix more joints or knots, beſides thoſe already taken notice of, making eleven in all; of which the ſixth *i*, the ſeventh *k*, the eighth *l*, the ninth *m*, and the tenth *n*, emit each four nerves, all diſperſed among the viſcera and the muſcular parts of the abdomen. Finally, the laſt knot, *o*, beſtows all its nerves upon the tail.

CHAP. II.

The manner in which the Caterpillar is changed into a Chryſalis or Aurelia, with the true explanation of what the Chryſalis is. This chapter contains alſo ſome anatomical obſervations, and ſome other curious remarks concerning the Chryſalis and Butterfly.

WHEN the Caterpillar has fed ſufficiently, it reſts for ſome time. In this period, all the food it has taken is thoroughly digeſted. It then forms a pretty ſtrong web upon the ſtalks or leaves of the plant whereon it fed: but this web, on account of its great delicacy, is not eaſily ſeen; unleſs the inſect be put into a little box, with a piece of black paper for it to work on. Then its web, however ſlight and tender it may ſometimes be, ſhews itſelf very plainly. This web being finiſhed, Tab. XXXV. Fig. IV. *a*, the Caterpillar ſtrikes into it the claws of the two legs under the tail, and afterwards forces in the tail itſelf, by contracting thoſe claws, and violently ſtriking thoſe legs againſt one another: and, as ſoon as the tail is thus well ſecured, it lets itſelf hang in the air, with its head downwards, by looſening the hold it hitherto kept of the plant with its other legs.

But I think it proper to deſcribe the limbs of the Caterpillar, that grow under its ſkin, before I pro-

I proceed any further in ſhewing how it throws this ſkin off; for it is neceſſary to know theſe particulars, in order to acquire a true and juſt idea of the nature of the Aurelia. This, indeed, is no more than a beautiful and orderly external repreſentation of ſuch limbs of the Caterpillar as have grown under its ſkin: for though the limbs, now mentioned, may be ſeen under the inſect's ſkin, at the time it crawls and eats in the form of a Caterpillar, nevertheleſs it is, in this ſtate, on account of their extreme tenderneſs and delicacy, a very difficult matter to have a ſatisfactory view of them. They are, in a manner, as fluid as water; and they lie folded up in many very tender membranes, interwoven with pulmonary tubes. The beſt time to obtain an elegant view of them, is when the Caterpillar is juſt about throwing off its ſkin, and exhibiting to open view the miraculous operations of nature, which it hitherto concealed.

By ſtripping the Caterpillar of its ſkin at this period, we may perfectly gratify our curioſity in this reſpect: we may then plainly perceive, that it has two antennæ or horns, Tab. XXXV. Fig. II. *aa*, and the two ſhanks of a trunk, *bb*. There are alſo viſible two ſharp protuberances, *cc*, which may be very well called the forks, or furcillæ of the future inſect, on account of their great reſemblance to thoſe parts. The eyes, *dd*, ſhew themſelves alſo, under theſe protuberances; and a little backwards, in the thorax, are four wings, *ee*. Theſe lie in folds under the ſkin, like all the other parts, ſo that they may be conſiderably extended. Near theſe wings there appear ſix legs, ſpringing from the thorax: theſe have changed their ſkins. All the other ten legs, with their integuments, have now been thrown off, with the common ſkin; of which, as already obſerved, it is neceſſary, upon this occaſion, to ſtrip the inſect. The ſame happens to the ſharp-pointed hairs that grow on the Caterpillar's back; but theſe laſt leave very conſiderable marks behind them. Laſtly, the other rings of the body, *ff*, and the tail, *g*, ſhew themſelves in their proper places.

Having duly attended to the foregoing particulars, and fixed them deeply in our memory, as the foundation on which it is intended we ſhould build all our future inquiries; the next buſineſs is to obſerve, how wonderfully all theſe parts are placed and diſtributed under the ſkin. But here I muſt obſerve, that they do not naturally lie in the ſame order and manner in which, for the ſake of perſpicuity, I have repreſented them; ſo far from it, that the extremities of the four wings are encloſed in the ſame ſkin with the four hinder legs of the firſt ſeries; and the horns, trunk, and furcillæ, are folded and laid up within the ſkull in a moſt ſurpriſing manner.

Theſe little horns, or antennæ, are fixed by an articulation, Fig. III. *aa*, to the forepart, at the baſe of the head, where they form ſome windings and turnings under the ſkull near the eyes, and againſt the baſe of the trunk; to all which parts they are faſtened, by means of a great many membranes full of ligaments. This is their natural ſituation; from which I have been obliged to deviate in my delineations, the better to exhibit the other parts which they cover, and likewiſe becauſe I cannot now ſpare the time requiſite to make two drawings, which it would be otherwiſe neceſſary to give. The proboſcis, or trunk, Tab. XXXV. Fig. III. *bb*, is folded up alſo in a ſurpriſing manner, and placed in the forepart of the ſkull; but here I repreſent it as drawn out a little. The forks, or furcillæ, likewiſe, *cc*, are plaited and folded up. Under theſe forks lie the eyes, *dd*. We may perceive, in the middle of the head, that portion of the ſkin which lies under the middle of the ſkull, *e*, and there joins the root of the trunk or proboſcis, *ff*. Between the foldings of the proboſcis appear two ſmall parts, lying againſt each other, *g*. Theſe are called furcillæ in the Butterfly, becauſe the trunk, when curled, hides itſelf between them, as between the two tines of a fork. All theſe things are ſo wonderful, that I have thought it beſt to repreſent them larger than the life.

The particulars here named, being rightly underſtood, the change, or, to expreſs myſelf more properly, the growth of the creature from the Caterpillar-ſtate into an Aurelia, cannot but appear plain and intelligible; for the whole operation conſiſts in this, that the Caterpillar caſts its ſkin, and ſhews the parts which hitherto lay concealed; unfolds its limbs, and arranges each in its right place with great regularity and order. This is the whole operation, to which ſo many authors have ſubſtituted a monſtrous metamorphoſis, or abſolute change of one creature into another, not to be found any where but in their own miſguided imaginations. What wonder then, if, in their vain and idle attempts for ſome hundred years paſt to explain this metamorphoſis, they ſhould have met with no ſucceſs? Thus it is, that we are apt to err, when, depending too much on our own reaſon and imaginations, we ſit down contentedly in our ſtudies, and feed ourſelves with our own weak fancies, inſtead of looking for truth into the magnificent works of the Creator, though ſuch inſpection alone can give us juſt notions of what we deſire to know.

There is no difference between the Chryſalis and the Caterpillar, but that the former lets us ſee more plainly the limbs and parts of the future Butterfly, notwithſtanding the ſkin, which yet encloſes them. For as ſoon as the Caterpillar has finiſhed its web, Tab. XXXV. Fig. I. *a*, and has fixed in it, by means of its crooked claws, the hinder part of its body, it lets itſelf looſe, and hangs head downwards, as already mentioned, contracting itſelf almoſt into a ſemi-circular form. In this condition the creature grows ſhorter, and ſmaller, by degrees; and this indeed ſo ſenſibly, that the eye may eaſily trace its progreſs: for the third and fourth annular diviſions of the body, *b*, are ſo remarkably ſwelled and expanded at this time, by the blood and air that dilute the encloſed wings and legs, that the reſt of the body, drained of its juices, muſt of courſe become proportionably ſhorter. The ſame alterations take place in the trunk, the forks, the eyes, and horns; all which equally ſwell and expand themſelves, and endeavour to make way for their laſt increaſe.

By the time the Caterpillar has hung in this manner fifteen or eighteen hours, it ſo entirely loſes the power of all its ſixteen legs, as not to be able to make the leaſt uſe of them to crawl, or ſtand. The rings of its body then begin to move up and down, in a very ſenſible and ſurpriſing manner. Then the eight legs, *c*, in the middle of the body, grow leſs and leſs by degrees, caſt their ſkins, and are turned towards the tail, Fig. IV. *a*. The ſix fore legs, Fig. I. *d*, move upwards in like manner, and ſeparate themſelves from each other, Fig. IV. *b*. Soon after the black horny bone of the ſkull becomes ſplit into three diſtinct parts, by the ſwelling of the trunk, horns, and the other parts lodged there, that lie under it. Of theſe three parts of the ſkull, one is in the middle, *c*, and the other two, *d e*, are on the right and the left. This being accompliſhed, the firſt obſervable change is the breaking out of the forks, or furcillæ, from under the ſkin that covered them, *f f*.

As the Caterpillar ſtill continues to move its body, the four pair of legs in the middle of it, Fig. V. *a a*, are by degrees thruſt quite up to the tail, with the reſt of the ſkin; and the ſame thing happens to the two pair of the ſix legs of the firſt ſeries, *b*. By this means the forks, *c*, become ſtill more viſible, and the trunk, horns, and wings, begin to ſhew their form. Laſtly, the three pieces of the ſkull, *d*, into which it burſt, are found to be drawn up higher over the body.

The ſkins being at length entirely depoſited, all the parts, now mentioned, appear very plainly expanded over the body, Fig. VI. *a*, which, by this means, acquires a form altogether different from that which it before had. The wings, horns, trunk, and forks, which before were folded up and hid under the ſkull, and the horny ſubſtance of the legs, are now diſplayed; and the rings of the abdomen are alſo gathered up cloſer to one another. The Caterpillar is now dignified with the name Aurelia, remaining all this time fixed to the web, *b*, by its claws. But as this cannot be ſo well made to appear by a figure no bigger than the inſect itſelf, I ſhall give a drawing of theſe parts as magnified by the microſcope.

In the firſt place appear the furcillæ, or forks, Tab. XXXV. Fig. VII. *a a*; then the middle part of the head, placed under the ſkull, *b*: the root of the trunk, *c c*. The proboſcis, or trunk itſelf, divided into two filaments, *d d*, and ſtretched lengthways upon the body, *e*. Under the trunk lie the firſt pair of legs, *f f*, whoſe articulations are placed a little lower. Next to theſe are placed the ſecond pair of legs, *g g*, which are ſtretched out to a greater length, and theſe ſhew their articulations at the extremities. Near theſe are placed the little horns, *h h*, whoſe articulations alſo are very conſpicuous. It appears that they are very thick near their points, *i i*, and on the forepart they bend themſelves back under the eyes, *k k*; but this circumſtance appears better in the third figure, under the letters *a a*. The wings are ſtretched along the ſides, in the ſame manner with the parts already mentioned, *l l l l*, and ſhew very plainly the little ribs or nerves that go to form them, *m m*. The rings of the abdomen appear drawn toward one another, *n n*, with ſome little prickles ſtripped off their ſkin, which look like ſo many little prominent nipples, or papillæ. This beſt appears by inſpecting the left ſide of the figure, where ſome of theſe prickles are repreſented growing upon the inſect's back, *o o*. Above theſe prickles there appear four breathing-holes, or puncta reſpiratoria. Laſtly, the tail, *p*, is very conſpicuous, as well as the claws, *q*, that grow to it; and by means of theſe the Chryſalis hangs to its web. The hind legs are not to be found in this figure, becauſe they lie hid under the other parts which it was drawn to exhibit. The ſame muſt be underſtood of the under pair of wings.

On turning the inſect, thus changed and ſtripped of its ſkin, Fig. VIII. *a*, on its belly, it appears of a very extraordinary figure, the ſurface of it looking exactly as if covered with prickles and nipples; which is owing to this, that the ſharp-pointed hairs of the Caterpillar have caſt a ſkin, as well as the other parts. A perſon, unacquainted with this branch of natural hiſtory, might, by giving in this place a little looſe to his imagination, repreſent to himſelf the noſe, eyes, and other parts of the human face, as ſome authors have already very ignorantly done; nay, they have given drawings of their idle conceits.

Ignorance is fruitful in falſe opinions, and is uſually accompanied with ſo much ſelf-ſufficiency, as makes it in a manner impoſſible to overcome its prejudices; whereas thoſe who have a tolerable ſhare of knowledge, are in the readieſt way to diſcover their miſtakes.

The Caterpillar, ſtripped of its ſkin, in the manner now related, is of a green colour, eſpecially in thoſe parts which are diſtended by an extraordinary afflux of the blood. But after ten or twelve hours paſſed without its ſkin, it turns to the moſt reſplendent and beautiful gold colour. This is the reaſon of its being called, in this condition, an Aurelia or Chryſalis. And as it is found ſo common by every pathway, ſticking to nettles, and ſhining like poliſhed gold, faſtened to the leaves of the Pervinca, or periwinkle-plant, authors have, from this circumſtance, taken occaſion to give the name of Aurelia to all Caterpillars, changed after the ſame manner in point of ſhape, tho' the greateſt part of them do not in the leaſt partake of this rich colour, and the reſt have nothing of it more than a few ſpots.

It now remains that I ſhould ſhew, in a few words, in what manner all the laſt enumerated parts are extended, and diſpoſed over the inſect's body, in the orderly manner in which I have exhibited them. All this will become very intelligible to thoſe, who will call to mind what I already ſaid, viz. that the extremities of the four wings, with the two hinder pairs of legs of the firſt ſeries, are encloſed in one and the ſame ſkin; that the horns are folded up in membranes full of ligaments; and that the trunk is in the ſame manner firmly faſtened on the forepart of the ſkull. This being the caſe, it is impoſſible but that, on the pieces of the broken ſkull, the withered legs, and the other ſkins, rolling up towards the tail, all the new limbs, here mentioned, muſt diſplay and arrange themſelves in the moſt beautiful manner, and by the juſteſt and moſt orderly evolutions; for the membranes I have named, that are ſo full of ligaments, act the part of ſo many ropes and pullies to extend theſe new parts, in proportion as the old are thruſt over them. Now, if this change was to happen in ſome creature of a larger ſize, one, for example, equal to a Sheep or a Calf, is there any one ſo inſenſible, as that he would not be ſtruck with the deepeſt aſtoniſhment at the ſight and contemplation of ſuch wonders of the Divine Power? Certainly, God reveals himſelf as much and more in thoſe myſterious and delicate operations, which the microſcope alone can diſcover. Thus then, we at length ſee evidently in what the change of the Caterpillar into a Chryſalis conſiſts, and what that Chryſalis or Aurelia, or the Caterpillar which has caſt its ſkin, really is; though the great Harvey moſt prepoſterouſly conſidered it as an egg, and, enthralled by vulgar prejudices, ſeriouſly affirmed the ſucceeding Butterfly to be generated by a metamorphoſis, which, after all, he could neither explain or comprehend.

When the little creature has hung in the open air for ſome hours, its external skin hardens by the power of that element; at the ſame time that the encloſed limbs are, in a manner, fluid like water, on account of their great delicacy and tenderneſs; ſo that it has no power to move its wings or legs, till the ſuperfluous humidity, that clogs them, is evaporated: then burſting its priſon, it appears in the ſhape of a Butterfly; as ſhall be preſently explained *.

The anatomy of the Chryſalis, two days after it has caſt its ſkin.

THE eyes were yet ſo tender and delicate, that they diſſolved with handling. The forks likewiſe were very moiſt; but, notwithſtanding this, the articulations were very conſpicuous; though, for the greateſt part, they appeared like membranes, juſt beginning to harden. The legs were in the ſame condition with the forks; but, on account of the pulmonary tubes which appeared through their ſurface, they looked ſomewhat more firm. The ſame thing may be ſaid alſo of the horns. The wings within were quite colourleſs, and like a jelly; ſhewing, through their tranſparent ſubſtance, pulmonary tubes, compoſed, as it were, of mother of pearl.

As to the internal parts, the change in them is much more ſenſible. The ſtomach is conſiderably ſhortened, whilſt the gullet is grown twice as long as it was in the Caterpillar, and runs in the form of a ſlender tube through the thorax into the abdomen. In the hinder part, the ſtomach is reduced to a ſlender gut, and becomes ſo very tender, that it breaks with the leaſt touch: within this is found a fluid matter, of a deep red colour, inclining to purple, but not very thin. Under this there appears a kind of chalky ſediment, of a ſomewhat paler colour. The ſix cœca, or cloſed guts, that before joined the ſtomach, are now waſted away, and no longer to be ſeen.

The heart and the ſpinal marrow are become much ſhorter; and this is all the conſiderable alteration that appears in theſe parts. The particles, which I once miſtook for the Caterpillar's ſilk-bags, are now become more ſlender, but more compact. The muſcles of the thorax, and thoſe which are to move the legs and wings, have not the leaſt ſtrength or firmneſs, ſo that on diſturbing them, they immediately fell to pieces. The fat is grown yellower, thicker, and more friable, ſo as to crumble with the lighteſt touch. The pulmonary tubes are become ſmaller, and they are carried in the moſt elegant manner through the legs, wings, and other parts. There is a purple nodule, or knot, in ſhape nearly round, ſticking to the lower rings of the body. I could not now diſcover the kidney-like particles, though I ſearched for them carefully in three diſtinct Aureliæ: but I have obſerved in Caterpillars of another kind, that theſe particles at length unfold themſelves, and then ſeem to form ſome other parts, which adminiſter to the ſpermatick organs.

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* The repeated experiments of ſucceeding naturaliſts have, in every inſtance, confirmed the doctrine of this author on the preſent ſubject. The indefatigable Reaumur proved the truth of this evaporation of the abundant moiſture from the Chryſalis, by different experiments. He encloſed the Chryſalis in a glaſs tube, and he found the evaporated water collected in drops at the bottom of the tube: he covered the Chryſalis with varniſh; and this making the evaporation more difficult and ſlow, the Butterfly was two months longer than its natural time in coming out of the caſe. The ſame author found alſo, that laying the Chryſalis in a warm room, haſtened the diſcloſure of the inſect; and keeping it in an ice-houſe, in the ſame manner, delayed it. Warmth acts, in this caſe, in a double capacity, invigorating the animal, and evaporating the moiſture.

The anatomy of a Chryſalis, ſix or eight days after it has caſt its ſkin.

THE external limbs, and other parts, as the trunk, horns, legs, and wings, are by this time grown ſomewhat more dry and firm, though ſtill they are of a white colour, which is changing by degrees to gray. The alteration in the internal parts is now much more conſiderable. The ſtomach, which before might be conſidered as forming ſeveral diſtinct parts, is now ſo wrinkled up as to be all of a piece, except that here and there appear ſome globular ſwellings above the ſurface. Theſe prominences are very obſervable on the forepart; but not ſo diſtinctly to be ſeen, by a great deal, where the cloſed inteſtines took their riſe in the Caterpillar, about the hinder region of the ſtomach. The moiſture contained in this part is changed to a deeper purple. The muſcles of the thorax are become more conſpicuous, diſtinct, firm and ſolid; and the fat is ſtill more and more contracted into a ſimple maſs. I could now plainly perceive, that the purple nodule, or knot, was nothing more than a dilatation of the rectum, or ſtraight gut, changed to this form. The rudiments of the genitals are by this time very viſible, and have begun to acquire firmneſs and ſtrength.

The anatomy of a Chryſalis of twelve or thirteen days.

THE trunk, at this time, has acquired a conſiderable ſolidity. The horns ſhew their little ſcaly feathers; and the legs, in like manner, very plainly exhibit their ſtiff hairs, reſembling briſtles: but the ſcaly little feathers are far from being ſo conſpicuous. The legs are alſo now of an obſcure gray colour, eſpecially about the joints neareſt the thorax. The hairs and little feathers of the wings are likewiſe very diſcernible; but, as yet, they are very moiſt, and are laid ſo cloſe one upon the other, that it requires ſome induſtry to get a ſight of them. They reſemble, in ſome meaſure, the hairs of a Cat; in which, after the ſkin has lain in the water for ſome days, they are faſtened together by the moiſture they imbibe. The wings now will admit of being extended, and ſhew, if they be torn, their pulmonary tubes, and other veſſels. Their colour is an aſhy gray, but obſcured by a duſky tinge. All the parts I have mentioned are quite complete, and perfect, in a Chryſalis of ſixteen or ſeventeen days old. By repeating this diſſection every day, we may, no doubt, obſerve the moſt extraordinary tranſitions, that can be imagined, from one colour to another; for, from a pale and whitiſh or faint gray, theſe parts change to a dark colour, a deep brown, an elegant red, a yellow, a ſky-blue, a bright white, and many other tincts; and this in ſo ſurpriſing a manner, that it is almoſt impoſſible to deſcribe it: GOD, the author of all miracles, producing theſe alterations, in the nature of things, by rules which, at the ſame time that they are moſt firmly eſtabliſhed, infinitely ſurpaſs the ſtrongeſt efforts our imagination can make to comprehend them.

The anatomy of a Chryſalis, of this ſpecies, of ſixteen or ſeventeen days old; at which time it is very near undergoing its laſt change, in order to become a perfect Butterfly.

ON examining the Chryſalis at this period, we find, that its gold colour is become much paler; and it is ſo tranſparent withal, as to let us perceive diſtinctly through it all the colours of the upper pair of the future Butterfly's wings. If we ſtrip off the ſkin, and other thin membranes that ſheath the wings, theſe laſt ſometimes appear perfectly dry. But this principally happens in autumn, when theſe Chryſallides are generally ſuffocated within their ſkins; the ſolar heat, at this ſeaſon, being too weak to ſtrengthen them ſufficiently for the ſtruggles which the burſting of their priſon requires, otherwiſe the wings always retain ſome moiſture. The forky particles, which I have before deſcribed in the Chryſalis, now ſhew themſelves hollow; and the eyes, which, like thoſe of Bees, are ſurrounded with hair, appear under them very plainly. The trunk has acquired its due ſtrength, firmneſs, and form, ſo that it preſently curls and coils itſelf up, on taking off the caſe that covers it. Under the trunk are to be ſeen the true forks, between which the Butterfly hides that curious organ, as will appear in the deſign I ſhall give of that inſect. The horns alſo are now perfect, and are covered with their little elegant ſcales, which reſemble feathers. The legs, with their little feathers, joints, and claws, are in the ſame ſtate of perfection; ſo that, on ſtripping off the coats and membranes in which they are bound up, they will begin to play, and move themſelves very ſenſibly. Thoſe legs, which, in the Chryſalis, lie moſt expoſed to the air, and which I have already repreſented in one of theſe deſigns, as they appear upon the inſect at that period, have in proportion a ſtronger skin to defend them. The ſame wiſe diſpoſition is alſo remarkable in the ſkin that defends the upper and lower pair of wings,

wings. When we examine the internal parts, it appears that the eyes are perfectly formed, being replete with thin pyramidal filaments, in the ſame manner as thoſe of the common Bee, as already mentioned. There are in the trunk two channels, which, uniting, form only one in the thorax, and conſtitute the gullet, which ends at the ſtomach. The muſcles of the thorax have acquired their due firmneſs, and conſiſt of three kinds of fibres; ſome running lengthways, others tranſverſely, and the third kind obliquely. Near the gullet appear the three little particles, which I took for the Caterpillar's ſilk-bags. They are at this time curled into one, and are inſerted near the end of the gullet, to which they are united on each ſide. A bladder full of wrinkles, and endued with a periſtaltick motion, is now ſeen on the upper part of the ſtomach; and it communicates with the gullet, by means of a ſlender tube. This bladder, the ſtomach, and ſome part of the gullet, are full of a deep purple moiſt ſubſtance; but the upper part of the gullet has nothing beſide air in it. The ſtomach, being gathered up into one maſs, in a ſurpriſing manner, looks as if quite covered with tubercles. The back-part of it, like a little gut, is now become much more ſlender and ſhorter, and is wrinkled withal, ſo as to deſerve the name only of an inteſtine. The vaſcula cœca, varicoſa, or crocea, which were dropped from the ſtomach, appear now in the ſame place. Next were to be ſeen the inteſtina craſſa, or large guts, which, from being very ſhort in the Caterpillar, are now become very long and ſlender, and appear as if they had been ſtretched out to give them ſuch an extraordinary length. They then dilate into a nodule, or knot, full of the purple matter already mentioned; and that dilatation is followed by another, greater than the firſt; but its contents are the ſame. The Chryſalis, on caſting its skin, diſcharges this liquid from the anus; by which means the nodule, or knot, next to it comes to be ſmaller than the other. This excrementitious ſubſtance, laid upon paper, looks like real blood. The ſtomach, of the Aurelia I am deſcribing, is much more firm, and of a much better conſiſtency, than that of the Aurelia of two days already ſpoken of; inſomuch that it may be now handled with the forceps, and drawn out of the body with the inteſtines that are joined to it, without any damage or danger.

The heart and ſpinal marrow are now quite contracted, and conſiderably diminiſhed. The fat is ſurpriſingly waſted away, and wrinkled up by evaporation, ſo as to reſemble a bunch of yellow oblong grapes, which are ſo firmly faſtened to the pulmonary tubes, that the greateſt care and patience is requiſite to part them. There appeared no other alteration in the pulmonary tubes but this, that they were grown more membranaceous, and ſhew more diſtinctly their muſcles, and other parts, which had now acquired their proper degree of perfection. The kidney-like particles are now no longer to be ſeen: perhaps they have been expanded by a ſlow growth into the organs of generation, which now ſhew themſelves very diſtinctly; but are ſo intimately united with the fat and pulmonary tubes, that it is almoſt impoſſible to ſeparate them, unbroken and entire. This makes it neceſſary to attempt the diſſection of the genital parts in the Butterfly itſelf: I therefore hope, that, when I ſhall have proceeded ſo far, I ſhall be able to give a ſatisfactory deſcription of theſe parts, with figures to illuſtrate the accounts; provided my health does not fail me, and I do not want proper ſubjects to work upon. I ſhall likewiſe deſcribe at the ſame time, and in the ſame manner, the gullet, ſtomach, and inteſtines, with figures of them.

In what manner the Aurelia aſſumes the form of a Butterfly.

WHEN this, as I may juſtly ſay, ſurpriſing alteration of the inſect, by the growth, and removal of the limbs, and other parts, happens in the month of June or July; it requires only about eighteen days to perfect it in this ſpecies: whereas late in autum, it requires ten days more; ſometimes indeed a great number of Caterpillars, by not beginning to change till the ſeaſon is thus far advanced, periſh for want of ſtrength to caſt their ſkins; ſo that, on this occaſion, theſe little creatures are liable to the common calamities of nature, and very often come to an untimely end.

Nothing is more remarkable about the time when the Aurelia begins to caſt its ſkin, than the perfection to which the wings, which have grown under it, are arrived. The colours that adorn them are chiefly black, red, and a ſky-blue; and theſe, as well as the trunk, legs, and horns, may be very eaſily diſcerned through the ſkin that covers them, even without the help of a microſcope, Tab. XXXV. Fig. IX.

On examining, with a microſcope, the Chryſalis at this period, the extremities of its legs are obſerved to move very diſtinctly: a circumſtance which I have often remarked in the Aurelia of Silk-worms, with the greateſt aſtoniſhment.

The colours of the under pair of wings cannot be ſeen, becauſe they are altogether covered by the upper pair; nor are the colours of the other parts, juſt now mentioned, very diſcernible, becauſe there is not ſo great a variety of tincts in thoſe parts. For though the colour of all Chryſallides appear through their ſkins, at the time they are going to caſt them off; nevertheleſs, it is impoſſible to tell exactly what thoſe colours are, where there does not happen a conſiderable diſtinction between them and the ſtain itſelf.

While the little creature remains in this condition, there is a violent agitation in its blood, and a motion in all its internal parts. The blood, in a haſty fermentation, is driven through the veſſels from the heart into the wings, which are likewiſe ſupplied with air from the lungs. The inſect, beſides, labours violently with its legs: and all theſe motions concurring with the growth of the wings, it is impoſſible the tender ſkin that covers it, ſhould not at length give way; and this it accordingly does, by burſting into four diſtinct and regular pieces.

Firſt, That part of the ſkin which covers the trunk, the two fore-pair of wings, the horns, and the furcillæ or forks *, falls off from thoſe parts; but the ſeveral portions of it, in which they were ſeparately wrapped up, remain firmly united together, Fig. x. *a.* This is the firſt time the legs appear without any covering, and they then help greatly to free the body, and the other parts that remain yet bound up. At the ſame time, the ſkin on the back flies open, and dividing itſelf into two regular portions, *b b*, diſengages the back and the wings. Then there likewiſe happens another rupture in that portion of the ſkin, which covered the rings of the back of the Aurelia, *c.* After this the Butterfly remains very quiet for ſome time, with its wings pointed downwards, and its legs fixed in the ſkin which it has juſt caſt off.

But it muſt be obſerved, that the wings, legs, horns, trunk, and other external parts of the Butterfly, do by no means riſe from the body in the manner exhibited in the II Figure of the Table XXXV. where I have laid down all thoſe parts, as they appear very diſtinct and conſpicuous in the Caterpillar itſelf. Many of theſe parts remain as has been already ſaid, firmly united to each other, the reaſon of which is, that they are all moiſt and wet in the Caterpillar, at the time when it is about throwing off its ſkin, and becoming a Chryſalis; and this moiſture being of a clammy or glutinous nature, ſerves, on its being dried by the air and heat of the weather, as a real glue, to unite the parts it lies between ſo firmly together, that they never ſeparate for the future. Now, as the ſkin, which lines all theſe parts, or covers them on the inſide, is extremely delicate and tender, which it well may be, as it is not expoſed to the air, it all breaks and flies off without any certain order; nor is any order neceſſary upon the occaſion. Hence it ariſes, that ſo many broken and ragged little membranes, almoſt as thin as a cobweb, appear on the inner ſurface of the ſkin that has been thrown off. One of theſe little films is to be ſeen between the conglutinated coats or ſkins of the trunk, horns, and other parts, Tab. XXXV. Fig. x. *d.*

There likewiſe appear within the ſkin certain white filaments, *e e.* Theſe are the caſt coats of the pulmonary tubes; for now theſe tubes caſt their ſkins for the laſt time. The greateſt part of the eighteen pulmonary tubes, of which I have repreſented nine on one of the ſides of the Caterpillar, in the ſecond figure of the XXXIV. Table, remain in the Aurelia, which breathes by them, until by caſting this ſkin it becomes a perfect Butterfly; and this is the reaſon, why the pulmonary tubes are much more ſlender in the Butterfly, than they were either in the Caterpillar, or the Chryſalis: this circumſtance alſo affords the Butterfly the means of taking more air into its body, and thereby renders it the better able to fly, to give a due motion to the contents of its inteſtines, to ſuck in the juices on which it lives, to void its excrements, and to perform many other operations neceſſary in the animal oeconomy.

At the time when this change of skin happens, the wings expand ſo rapidly, that the naked eye cannot trace their unfolding, from reaching ſcarce half the length of the body, Tab. XXXV. Fig. XI. *a*, they acquire, O miracle of miracles, in the ſhort ſpace of about half a quarter of an hour, their full extent and bigneſs; ſo as to be each of them five times larger than they were before. Nor is it the wings alone that are thus increaſed: all their ſpots and colours heretofore ſo minute, as to be ſcarce diſcernible, *b b*, are proportionably extended; ſo that what but a few minutes ago, appeared but as a number of unmeaning confuſed points, are now become diſtinct and moſt beautiful ornaments. All this may be beſt conceived, by conſulting the XII Figure, which repreſents the wings bigger than the body, and with all their colours, which are chiefly red and black. About the edges, however, here and there ſome yellow, sky-blue, and white ſpots, are ſeen moſt elegantly combined, which exhibit to us, though faintly, and as it were by ſhadows, the inexhauſtible treaſure of the Great Creator's treaſures, his ſtupenduous majeſty, and his other incomprehenſible perfections; for though no adequate repreſentation can be given of the Supreme Being, he has thus been pleaſed to ſhew himſelf to us, diſtinctly and conſpicuouſly enough to engage our love, our adoration, and our gratitude.

This little creature is found alſo to have four legs, Fig. XI. *c c c c*, each armed with claws, and adorned with hairs, and a variety of colours. The two horns *dd*, lie juſt above the eyes: near the ſpace between the eyes, are to be ſeen the forks or furcæ; from between which the inſect darts *e* out a double trunk, the uſe of which is to pump out the ſweet juices from flowers into its body, ſo that this organ may be conſidered as its tongue. When this curious part is not at work, it lies ſo cloſely curled and coiled up between the forks, that it cannot be ſeen. This beautiful contrivance is repreſented in the XIIth

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* Theſe appendages to the trunks of Butterflies have been ſuppoſed by ſome to aſſiſt in the procuring, diſpoſing, or forcing down the food: but the nature of the Butterflies food is a plain contradiction of that opinion; for it is only a liquid, and thin honey juice. Reaumer has therefore, with more juſtice, alloted them the office of preſerving the trunk from injuries, and ſupporting it in its intended uſe. This is confirmed by the conſtant obſervation, that theſe pieces or forks are always ſtronger in proportion, as the trunk is more tender.

Figure, in which we likewiſe ſee, that the Butterfly's wings entirely cover its legs. The firſt pair of legs lie nearly under the thorax; but they are now ſo altered, as not to deſerve that name; for the Butterfly makes no uſe of them as legs, nor have they claws like the others: nature, indeed, ſeems to have intended them for ſome other purpoſe.

As the wings extend themſelves ſo ſuddenly, they accordingly appear at firſt like pieces of wet paper, ſoft, and full of wrinkles, cavities, and ſwellings, as I have repreſented them in Tab. XIII. Fig. ix. x. xi. But they are quite dry in half an hour, by which means all the inequalities in them entirely diſappear, ſo as to leave them perfectly fit for the creature's ſervice. The Butterfly's tranſmutation being thus perfectly finiſhed, it diſcharges three or four pretty large drops of a bloody liquid, which are the laſt remains of the ſuperfluous moiſture, the reſt of which has been evaporated by the Aurelia during the heat of ſummer, in the ſpace of about ten days; for as the parts, which this moiſture was intended to expand, no longer need any increaſe, what remains of it is no other than an uſeleſs encumbrance, and accordingly it is expelled from the body as an excrement.

Thus the Butterfly, in a little more than a quarter of an hour, acquires its full perfection. During the Caterpillar-ſtate, it may be conſidered as a newly conceived embryo. In that of an Aurelia, it repreſents a child as yet ſhut up in the womb, but about to break the membranes in which it is bound up, in order to make its eſcape. Laſtly, the inſect, when employed in extricating itſelf from its integuments, reſembles the infant juſt coming into the world. However, there is this conſiderable difference between them, which well deſerves attention. The Butterfly does not produce itſelf like our wretched offſpring, weak, tender, and in a manner but half perfected; but, almoſt from its firſt moment of appearance in this ſtate, it is a complete creature of manly age, if I may be allowed the expreſſion, and qualified in every reſpect to avoid ſuch things as are hurtful, and look out for thoſe that tend to ſecure its exiſtence, for the ſpace allotted by nature, and make it agreeable.

Whoever conſiders theſe particulars attentively, muſt obſerve, in this poor inſect, a great and indeed immenſe degree of perfection, which man, the greateſt work of the creation, entirely wants. And this proſpect ſhould fill us, miſerable mortals, with ſentiments of the moſt profound humility. We ſee a little inſignificant inſect, diſtinguiſhed from its laſt birth, with qualifications, ornaments, and perfections, which, during our ſtay upon earth, however long it may be, we can never flatter ourſelves with the hopes of enjoying.

This creature, to ſupport life, needs no other food but the dews of heaven, and thoſe limpid diſtilled juices, which it finds ready prepared for its uſe by the beneficent ſun, and plentifully ſtored up in every flower. No theatrical ſcene can be imagined equal to the ornaments with which it is cloathed; and that its wings, and the rich colours that embelliſh them, were beſtowed upon it merely for the ſake of ornament, appears from its being able to fly with but two, as well as with four wings. The skies are the Butterfly's proper habitation, and the air its element; whilſt man, miſerable in every reſpect, is obliged to earn his bread with labour and cares: he comes into the world naked, and deſtitute of all external ornaments, to demand attention; and, born in this wretched condition, he roves about without habitation or ſhelter, expoſed on the one hand to the heat of the ſun, on the other, to the damps and exhalations of the earth, both enemies alike to his happineſs and exiſtence.

Indeed, upon mature thought, we have no cauſe to be ſurpriſed at this difference. We are at preſent exiles from heaven, our proper home; ſtripped of that beautiful cloathing which our firſt parents poſſeſſed. But this is not the only creature, from whence we may draw uſeful inſtructions. All other kinds of inſects are generated in the ſame manner. Not one of them grows the value of a ſingle line, after the half hour that immediately ſucceeds their extricating themſelves from their skins for the laſt time. We admire with the greateſt aſtoniſhment, how the bodies of the flying inſects could be contained in the little skins and membranes, out of which they came to appear in this ſtate; whereas the wonder conſiſts entirely in their expanding ſo much, and acquiring ſuch perfections in the firſt few minutes that ſucceed their enlargement.

How then can we avoid crying out, O God of miracles! how wonderful are all thy works! how beautiful are the ornaments! how well adapted the powers which thou haſt ſo profuſely beſtowed upon thy creatures! They are all, notwithſtanding, ſubject to decay and deſtruction; and, with all their perfections, ſcarce deſerve to be conſidered as ſhadows of the Divine Nature. It is therefore, with the higheſt reaſon, that a certain writer has ſaid, That all nature is over-run, and covered with a kind of leproſy. This is her old garment, which ſhe is one day to throw off, and its heavineſs alone is ſufficient to weigh down our ſenſes, and diſturb our reaſon, in ſpite of all its efforts.

Goedaert deſcribes the Caterpillar I have here been figuring, and the Butterfly ariſing from it, in the xxi. experiment of the firſt part of his natural metamorphoſes; but he forgot in his figure the Caterpillar's prickles, inſtead of which, he gives it nothing but ſimple hairs. He has, beſides, been guilty of another miſtake, in beſtowing breathing-holes on every one of the Caterpillar's rings. Mouffet alſo has favoured us with figures of the Caterpillar, and the Butterfly, and has deſcribed the Butterfly according to its colours. But Goedaert's drawing of it, deſerves the preference by many degrees.

The beauties of the Butterfly now before us, Tab. XXXV. Fig. xii. is but of a middle rank, if compared with that of many others. Its head is covered with little black hairy and ſcaly feathers; the eyes, which take up the greateſt part of the head, are thickly guarded alſo with hairs reſembling briſtles; and they conſiſt of a ſubſtance which looks like gold, on account of the brightneſs of the uvea, which is ſeen through. The thorax and abdomen, are black; but they are covered with hairs of a golden yellow. The legs and horns conſiſt of a black, bony, or horny ſubſtance, and are adorned alſo with ſcales and hairs of a gold colour. The wings look as if they had been ſlightly waſhed over with a deep red blood-coloured paint; and they have, beſides, four great and four ſmall ſpots of different forms. Near the thorax, the upper wings appear moſt elegantly ſprinkled and waved with glittering gold; and the lower wings near the belly, are covered with hair of a gold colour. The ſpaces between the ſpots of the upper wings inclines to yellow; but near the third pair of thoſe ſpots which lie towards the edges, are two other marks of a ſnowy white. The borders of the wings are elegantly indented, and ſet off with four principal colours, a black, a sky-blue, a peach-bloſſom colour, and a yellowiſh red. The sky-blue, by bending its courſe upon the black, which ſerves as a ground to the other colours, forms a beautiful creſcent; whilſt the other colours, making ſo many circles, ſeparated by the black ground, heighten the elegance of the diſpoſition in a very delicate manner.

CHAP. III.

Containing a deſcription of the internal parts of the male and female Butterfly, deſcribed in the preceding chapters.

HAVING deſcribed the external and internal parts of the Caterpillar, and of the Chryſalis, and alſo ſome of the Butterfly's external ornaments; my next task is to deſcribe its internal ſtructure; though I cannot ſay I have ſucceeded perfectly to my wiſhes, in examining and inveſtigating them one by one, as I propoſed to myſelf. For, as I did not begin to diſſect the inſect in this ſtate, till towards the end of Autumn, and had ſuch only to diſſect as had been changed to Butterflies within doors, and under my inſpection, and had not acquired their full perfection; for this kind of Butterfly outlives the year in which it makes its firſt appearance I could not therefore obſerve all its parts ſo accurately as I wiſhed: beſides, there was no bright weather during the time my examination laſted; but the air was continually darkened with rain and clouds. However, ſome things in my obſervations appeared worthy of notice, which I ſhall now briefly relate.

On opening the Butterfly's back, there immediately appear in the thorax, ſome little wrinkled veſſels, Tab. XXXVI. Fig. I. *a a*, which lie near the gullet, and have their inſertions in the forepart of the body. I take theſe little veſſels to be the ſame with thoſe already repreſented in the vth Figure of Table XXXIV. Their beginning is a ſlender little channel, *b*, which divides into two fine tubes; and theſe tubes again dilating themſelves, *c*, terminate at laſt about the beginning of the ſtomach, *d*; and they are ſo firmly united and faſtened to it, by means of the fat and muſcles, that I have not yet by any means been able to looſen them from that part, or to trace them higher. What greatly increaſes the difficulty is, that the beginning of the ſtomach itſelf, is here very ſtrongly connected. What the office of thoſe veſſels is, and whether they may not be the ſalival ducts, I cannot take upon me to determine; for I know not how they terminate in front, or whether or no they have a communication with the trunk, *e e*.

Amongſt the curled veſſels I have been treating of, appears the gullet, *f*, which dividing in the upper part, near the root of the trunk, into two little tubes, conveys to the ſtomach the juices ſucked in by that organ. From the lower part of the gullet near the ſtomach, there iſſues a ſhort and ſmall channel, *g*, which ends in a little ſlender bag, *h*. This bag is no other than an air-bladder, into which the air ruſhes, whilſt the inſects food is making its way to the ſtomach. This bladder is endued with a very conſiderable periſtaltick motion: it is almoſt always found in the Butterfly's back, placed over the ſtomach. In the Chryſalis, I found it full of a deep red liquid, as has been already obſerved.

The ſtomach itſelf, *i i*, is ſtrangely altered in regard to ſhape, from what it was in the Caterpillar, as before repreſented in the IVth Figure of Tab. XXXVI. It is now entirely ſwoln and tuberous, and it reſembles an inflated large gut; ſo that, on account of its many folds, hollows, and wrinkles, it exhibits a very pleaſing ſight in the hinder part. It ſo much reſembles one of the ſmaller inteſtines, *k*, full of moſt delicate folds, that I cannot take upon me to determine whether or not it ought to be conſidered as ſuch, rather than as a portion of the ſtomach. Under the pylorus, appear ſix inteſtina cœca, or vaſa varicoſa, *l l l l*, which are much more ſlender in this ſtate, than they were in the Caterpillar, and of a perfectly different form. They are likewiſe ſeparated here from the ſtomach, to which, in the Caterpillar, they always cloſely adhered by means of the pulmonary tubes. I have not as yet been able to find out where and how they terminate in the Butterfly, ſo that I ſhall only repreſent them here as they appeared to me on this diſſection. Under theſe lie the ſmaller inteſtines, *m m*, which are tranſparent and full of a globular ſubſtance. A little lower the gut widens conſiderably, ſo as to form the cloaca, *n*; then it contracts again, to dilate a ſecond time into a leſſer ſinus, *o*, in which it terminates. Next follows the ſtraight gut, *p*, terminating in a ring, of a ſubſtance between bone and horn, which forms the anus, *q*, is covered with hair, and drawn up within the abdomen. At the ſides of the anus appear its proper muſcles, *r r*: their tendons are black, and of a ſubſtance like that of the anus itſelf. The two dilatations of the inteſtines, which I have juſt now taken notice of, ſupply the place of a colon, which appears only in the Caterpillar; for in the Butterfly it is ſo transformed, as deſervedly to be conſidered as a different part. Certainly the ſurpriſing and incomprehenſible changes of parts which we here obſerve, ſhould engage our utmoſt attention, though for many reaſons, yet for none ſo much as for this, that they moſt evidently demonſtrate to the whole univerſe, the excellency of the Great Creator. The contemplation of theſe wonders has often led me to conſider, whether the entrails of Nebuchadnezzar, when deprived of his reaſon, and armed with talons, like a bird of prey, covered with hair, ſuch as is found upon beaſts, and condemned to eat graſs in common with the cattle of the field, did not ſuffer a change in his internal parts, correſpondent to that which appeared in his external form; and ſuch a change as might ſuit them to digeſt the food, with which his life was to be ſupported, in the courſe of this his moſt examplary penance. At leaſt there appears an occaſional alteration of this kind in the entrails of theſe inſects; for, as long as they continue under the form of Caterpillars, and live upon a groſs and earthy food, their entrails are alſo groſs and earthy; whereas theſe creatures, aſſuming a more delicate form, and beginning to ſubſiſt on a more pure ſubſtance, the organs by which ſuch ſubſtance is to be taken in, digeſted, and diſtributed to the ſeveral parts of the body, become likewiſe more delicate, and that indeed to ſuch a degree, that the alteration would never be credited, if the eye did not trace its gradations from one day to another.

There is no part of the Butterfly that deſerves our admiration more than the trunk [*]. I have but rudely delineated this organ, becauſe I propoſed making many other figures of it, conſiderably bigger than the life, which, after all my pains, I have not been able yet to perform, on account of the badneſs of the weather, and the ſeaſon's being now ſo conſiderably advanced. That extremity of it, with which the Butterfly ſucks in its food, is particularly curious in its conſtruction: it conſiſts of a double tube, divided, as it appears, into many articulations. This conſtruction ſuits it to a great variety of motions, and in particular, makes it eaſy to ſtretch out, and curl up again. It appears, that when the Butterfly ſips up the honey or liquid ſugar upon which it lives, a portion of air mixes with and accompanies this through the trunk to the ſtomach. This may be ſeen by faſtening the Butterfly by its wings, with a very fine pair of iron pincers, and uncurling the trunk with a very fine needle, ſo as to bring the tip of it to bear upon a blade of graſs dipped in ſugar water; for the Butterfly immediately ſucks the nouriſhment that is thus offered; and, with the aſſiſtance of a microſcope, both that and the air that goes along with it may be traced in their courſe into the body: and this is a very entertaining ſight. Indeed Butterflies may be kept alive in this manner many days together: they will take ſo well to this way of feeding, that at laſt they will dart out of themſelves, without any compulſion, their trunk into the moiſtened ſugar, or honey water, thus offered them. Hence we may gueſs how fine and delicate the muſcles, veins, arteries, and nerves muſt be, by which this little organ is ſupported and governed. The very extremity of it is of a moſt amazing ſtructure. As for my part, I muſt ingenuouſly own, that neither my eyes, my hands, or my head, are equal to the taſk of inſpecting, handling, or perfectly deſcribing it: but even this weakneſs is an uſeful leſſon, ſince I learn by it, that all our boaſted knowledge and perfection in this life, is in the main but ignorance and miſery. Let it therefore ſuffice, that the things we ſee, are capable of conducting us, as it were, by the hand, to the knowledge of a much ſublimer being; and let this conſideration engage us, to adore the Divine Majeſty, according to the perfect rules he himſelf has been graciouſly pleaſed to preſcribe to us, and to perform, with due reverence, the penance enjoined us for tranſgreſſing his commands. This is the one thing neceſſary; all elſe is vanity of vanities, and altogether unworthy of our attention.

The genital organs of the male Butterfly.

ON diſſecting a male Butterfly of this ſpecies, four days after its laſt change, the genitals appear perfect in every reſpect. The penis, Tab. XXXVI. Fig. II. *a*, placed near the extreme rings of the body, has on each ſide two horny little bones, *b b*, of a pale brown colour, which cover it behind and in the middle. Theſe little particles have an articulation, with a border, *c*, of the ſame ſubſtance, which ſurrounds the penis like a belt There is near the two little horny parts, already taken notice of, another that is hooked, *d d*, and behind, is divided in two; by the parts of the penis, *e*. On raiſing the two firſt little horny bones, there appear two crooked little claws, whoſe buſineſs it is to grapple, and firmly hold, during the act of copulation, the loweſt abdominal rings of the female Butterfly. This action is particularly obſervable in the common white Butterflies; for the female of this ſpecies very often flies about with the male faſtened to her, his claws or hooks in this part graſping her genital parts cloſe to him, his head hanging down, and his wings quite motionleſs. The muſcles of theſe parts of the penis appear between, and have their inſertions in, the little horny parts already taken notice of. On the inſide, near the two little grappling claws, there appear ſome other parts belonging to the penis; but I could not examine them with the due exactneſs. The penis conſiſts partly of a bony and partly of a nervous ſubſtance. The former reſembles, in figure, the little bone we find in the penis of Dogs; and has at its extremity an opening, thro' which the ſoft and nervous portion of the penis is erected at the time of copulation. The root of the penis is likewiſe of a nervous ſubſtance, *f*, but more compact than that portion with which the erection is performed. Next we obſerve the baſe of the penis, *gg*, containing in one part a white ſperm, and in another part a thick fluid, divided into very minute granules; which, on letting it out by wounding the penis, ſhines like a white or ſilver ſand, *i*. I leave to others to inquire what this laſt ſubſtance may be. The penis appears, in this part, very elegantly folded and curled up into two branches, *k*, which afterwards form four others, whoſe origins are all very firm and ſtrong. I am not diſpoſed to affirm any thing as a certainty, concerning the nature of theſe laſt portions. The two ſlendereſt branches, which appear moſt cloſely twiſted one with another *ll*, look like ſeminal veſicles; for they contain a white ſpermatick liquid, conſiſting of very minute grains, connected together by a membrane. The two other branches may paſs for the vaſa deferentia of the inſect, *mm*; and the nodule, or knot, *n*, in which thoſe branches terminate, for the teſticle; ſo as to make it probable, that the Butterfly has only one teſticle. But theſe are only conjectures on a ſubject, concerning which I dare not advance any thing as a certainty.

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[*] The trunk of the Butterfly is indeed an organ of moſt wonderful ſtructure. It ſtands in the part of the head where a noſe might be expected, but it really is of the nature of a mouth; for all the food goes through it. The ſubſtance of the trunk is horny: the creature may be ſaid to unroll it, by ſqueezing the head; or it may be drawn out with a pin. After this, if any violence be uſed to the creature, the trunk will crack lengthways in the middle, and the ſlit will run preſently through its whole length, and divide it into two. Bonani hence ſuppoſed the trunk was really double in the Butterfly, or originally compoſed of two. Riget thought he had ſhewn, from unqueſtionable experiment, that the trunk of this inſect was ſingle, and that this ſplitting was the effect of the violence offered to it, and its own tender ſtructure. He had his followers, till Reaumer verified the firſt doctrine of Bonani by more accurate trials; and eſtabliſhed the true ſtructure of this part, which is, that it is compoſed of two delicate tubes, laid parallel by one another.

This globular portion, which I call the inſect's teſticle, is of a pale gray, with a tinge of a purpliſh colour, and it is ſurrounded by two coats. The outer coat is very fine, and is united with a great many pulmonary tubes. The inner coat is much thicker, and yields, on diſſection, a ſoft, clammy, and glutinous ſubſtance, no way fluid. Through this there run a great number of pulmonary tubes, of a bright ſilvery whiteneſs, variegated with ſome purple ſtreaks. Perhaps repeated diſſections may enable us to determine, whether or not this portion is to be really conſidered as the Butterfly's teſticle. Theſe parts are ſo firmly connected on every ſide, by means of the fat, and of the numerous pulmonary tubes, as to make it a very difficult taſk to diſplay them. The rectum, or ſtraight gut, opens under thoſe particles belonging to the penis, which conſiſt of a ſubſtance between bone and horn, already taken notice of. The pulmonary veſicle, that is ſituated forwards near the ſtomach, appeared to me full of air. The ſtomach itſelf looks like a bunch of grapes; and cloſe to it lie the cœca, or cloſed guts. The ſmall gut is conſiderably longer than the ſtomach, and ends in ſome dilated parts.

The preceding obſervations I made the ſixth of September on a Butterfly, which appeared, for the firſt time, as ſuch that very day, and had been changed from a Caterpillar into an Aurelia the 17th of the preceding Auguſt; ſo that its change, from a Caterpillar to a Butterfly, took up nineteen days.

The anatomy of the ovary of this ſpecies.

A Few days after, I opened a female Butterfly, reſembling ſo exactly, in its internal appearance, the male before diſſected, that at firſt I imagined I had again got a male under my hands, till the thickneſs of the body indicated the contrary; and ſoon after the diſcovery of the oviducts confirmed me in my laſt opinion of the inſect's ſex. There were, as yet, no eggs in theſe ducts, ſo that they appeared very like the genitals of the male; and, indeed, it was ſome time before I could be ſure that they belonged to a female. Many of the inſects, whoſe date of life is of ſome length, have no eggs in the beginning, or very imperfect ones. I have indeed obſerved, that almoſt all inſects die very ſoon after they have prepared their ſperm; unleſs when their ſperm, though viſibly formed, has not acquired its full growth; or when the inſects are to ſurvive the winter, in order to lay their eggs the enſuing ſpring; as is the caſe of the Butterflies which I am now deſcribing. Nor does it appear probable to me, that either the eggs of inſects, or the inſects themſelves, in the Caterpillar or Aurelia-ſtate, can endure that rigorous ſeaſon; for which reaſon the little creature, now perfect in the Butterfly-form, is doomed to the hardſhips of this ſevere trial. Hence it is, that at the approach of winter they take refuge in the hollows of trees, in ſtore-houſes, and ſummer-houſes in gardens, where their blood is condenſed by the ſucceeding colds, like olive-oil at the ſame ſeaſon, and becomes, in a manner, quite caked; ſo that they neither move nor eat till the returning warmth enlivens them. This I have often obſerved. They even diſcharge no excrements all the time. I have made many curious experiments upon Butterflies in this condition; but it would take up too much room to give an account of them in this place.

There are ſix oviducts, Tab. XXXVI. Fig. III. *aaaaa*, in the female Butterfly now under our inſpection, and theſe all terminate in one common paſſage, *bb*; ſo that, in this part, the oviducts reſembles a ſingle trunk, which is a hollow channel, ordained to receive the eggs in their deſcent from the others. On each ſide of the channel are five little tubes, *c c c c c*, with their extremities cloſed. Theſe open into the paſſage, and diſcharge upon the eggs, in their courſe, a glutinous matter, which makes them ſtick to the nettles upon which they are dropped. The conſtruction of theſe little receptacles of the viſcous matter is extremely elegant: they conſiſt of various dilated tubercles, with lateral ramifications, which are likewiſe dilated again, and ſerve, in my opinion, to ſecrete and elaborate the glutinous ſubſtance here ſpoken of. On the other ſide of theſe ducts there ariſes, from the ovary, a much more ſlender tube, *d*, terminating in an oblong bag, *e*. This contains, as it were, two different ſubſtances. The contents of the upper part, *f*, is yellowiſh; and, on endeavouring to extract it, the membrane, conſtituting the bag, ſhews itſelf to have ſome ſtrength. As for the yellowiſh ſubſtance, ſticking to the inſide, it looks very like the fat of the Butterfly. The ſubſtance, encloſed in the lower portion of this bag, reſembles a limpid humour, and appears as ſuch through the tranſparent *g* membrane that forms the bag. The other end of the little tube, juſt taken notice of, opens at its extremity into the external parts of the ovary, or the vagina, *h*, which has a little elegant horny bone, of a bright red colour, that extends from the womb to a conſiderable height within the vagina, and has an opening, which I have marked with the letter *i*.

All theſe parts of the ovary adhere ſo firmly together, by means of the pulmonary tubes, Fig. IV. *a a*, and fat, *b b b*, that I have often loſt my deſire of endeavouring to diſplay them, together with the hopes of being able to effect it: but patience, in the end, got the better of thoſe obſtacles.

Theſe little creatures are very readily killed, by dipping them into ſpirit of wine. They likewiſe die in a very ſhort time, on putting them into a box containing Brazil-ſnuff. I have obſerved alſo, that other inſects are ſubject to the ſame fate; though, at firſt, it was by meer chance that I diſcovered it.

I have thus briefly recounted what I have been able to diſcover, concerning this little creature, in the ſpace of a few weeks. But if I had been maſter of more leiſure, and the autumn had not come upon me ſo ſoon in the operations, I ſhould be diſpoſed to mention, more at large, many other things worthy of admiration, which fell in my way; though I have not yet examined them with the accuracy they merit. Such, for example, as the true manner of the Butterfly's wings acquiring their ſize with ſuch an amazing celerity; as well as the art by which the tubercles, bladders, and puſtules may be imprinted on the wings; how the Caterpillar may be delayed and haſtened in the courſe of its change; by what means all the colours, which appear through the ſkin of the Aurelia, may, in that ſhort time of their appearance, be ſo firmly fixed as never afterwards to grow and ſpread. I had beſides propoſed repreſenting, a great deal larger than life, all the ſpots, lines, and colours of this little creature; as likewiſe its hairs, feathers or ſcales, and pulmonary tubes, the articulations of its legs, and many other myſterious works of nature obſervable in it; all which I have elſewhere promiſed that I would ſome time or another deſcribe.

The End of the wonderful Hiſtory of the Diurnal or Day Butterfly.

An Animal in an Animal; or the Butterfly hidden in the Caterpillar; which is a third particular example, ſerving as an additional illuſtration to the ſecond method of the third order or claſs of natural tranſmutations.

TAB. XXXVII.

THOUGH, by the particular experiments before advanced, it has been juſtly ſhewn what changes of the third order are peculiar to the firſt and ſecond ſpecies or method of transformation; I ſhall here, by way of further proof deſcribe and figure the manner in which I can find a Butterfly encloſed and hidden in a Caterpillar, and perfectly contained within its ſkin. This I demonſtrated, in 1688, to thoſe eminent perſons Magalloti and Thevenot.

But before I proceed to this, it is neceſſary to obſerve, that the Caterpillar, Chryſalis, and diurnal Butterfly, which I exhibit in theſe figures, are the ſame ſpecies with thoſe which the diligent Goedaert has figured Tab. XI. Part 1. And the often celebrated and learned Mr. Ray, in his treatiſe on the plants owing about Cambridge, Page 134, has particularly deſcribed a Caterpillar of this kind.

Tab. XXXVII. N°. 1. I exhibit the egg of the ſaid Butterfly in its natural ſize. This egg, as I have deſcribed in general before, is really the Caterpillar itſelf, encloſed in this condition, and inveſted with a membranaceous cover, or integument. Indeed, this Caterpillar lies hid in its membrane, in the very ſame manner as the Nymph or Chryſalis does in its integuments. I have before treated this matter at large; and the whole will be again more accurately debated under the account of the fourth order: therefore I ſhall not here exhibit a more ample explanation thereof. I am now only to demonſtrate clearly, that the Caterpillar is the Butterfly itſelf, and that this Butterfly lies encloſed in the ſkin of that Caterpillar, in the ſame manner as the Caterpillar does in the cover or ſkin of its egg. And all theſe things will appear plainly from what ſhall be ſaid immediately.

FIG. I.

The egg of that Butterfly, which is repreſented in N°. VI. is expreſſed in this firſt enlarged figure; in the exact manner wherein it appeared under the microſcope. It is obſerved hence to be, as it were, conſtructed of fifteen ſmall ribs; each of which manifeſtly throws a ſhade on the adjoining membrane, ſituated between thoſe ribs: and hence it is, that, to a perſon looking at the egg, it appears, about the ſhady parts, to be divided by as many other ſmaller ribs. Theſe ribs, and the membrane of the egg between them, are alſo divided croſſwiſe by regular grooves or channels. It may be alſo ſeen how all theſe ribs concur, as it were, in a center toward the ſmaller extremity of the egg, and extend themſelves beyond its ſurface. This egg, when arrived at its full increaſe, is of a yellowiſh colour; but it is white, when it is freſh in the oviduct. That is, I obſerve that thoſe eggs in the oviduct, which are firſt to iſſue forth, are perfect; but thoſe that poſſeſs an higher place are ſmaller, though they are of the ſame figure with the former. Thoſe that are ſituated higheſt in the oviducts, appear ſquare; and ſuch as lie yet in the extremities of the oviducts are ſo wonderfully ſmall, that at length they become entirely inviſible. The ſame is likewiſe obſerved in the eggs of another Butterfly of this kind, but ſmaller in the body and wings. I ſaw thoſe laying their eggs in the month of May, and faſtening them to cabbage-leaves, in ſuch a ſituation as I have herein delineated the egg of this larger Butterfly; that is, ſo that the ribs run upwards, but the globular baſis poſſeſſes the lower parts: the ſame thing holds with reſpect to theſe eggs. As the Butterflies, iſſuing from theſe, are found all the year, it is probable they lay their eggs at various times. This, however, ſeems to be done chiefly in Autumn, when we obſerve their Caterpillars in much greater numbers than at any other ſeaſon.

N°. II. I exhibit the caſt and forſaken coat of what is called the egg, which a little before, I have obſerved, was the real Inſect or Caterpillar of the Butterfly; ſince this Caterpillar, like the Chryſalis, is found encloſed in its ſkin, even within the egg.

No. III. The Caterpillar of the Butterfly, or the Butterfly lying concealed in the form of a Caterpillar, is here repreſented as it appears at the full term of its growth. In order to demonſtrate clearly and diſtinctly, that this Caterpillar is the real Butterfly, and the latter again is the Caterpillar itſelf; I ſhall firſt deſcribe the external figure of that Caterpillar, which conceals the Butterfly within its ſkin. As the celebrated and learned Mr. Ray has, before me, very clearly and perſpicuouſly performed this taſk, I ſhall therefore make uſe of his words, deſcribing the Caterpillar in this manner. "If we conſider the bigneſs of the Caterpillar that feeds on cabbage, it is of a "middle ſize, between the largeſt and ſmalleſt "kinds; and is covered with whitiſh, thin, "ſhort hairs, no where cluſtered together or "entangled. The colour of the body is va- "riegated, and compoſed of black, yellow, "and blue; whereof the yellow deſcribes "three lines as long as the body, that is, one "in the middle of the back, and the two "others on the ſides oppoſite to each other. "Between theſe lie the black and blue: the "former painted in ſpots, the latter more "diffuſed. Theſe black ſpots alſo are protu- "berant above the reſt of the body; and out "of each of their centers, where they appear "blacker than elſewhere, they emit the hairs "before mentioned. The head likewiſe has "the three aforeſaid colours mixed together, "and it is covered with the like hairs. The "legs, being ſixteen in number, are orderly "diſpoſed into three claſſes: the firſt of which "claſs is compoſed of ſix, annexed to the "head, near the breaſt: the ſecond conſiſts of "eight, on the belly; and the third of only "two, joined to the extremity of the body. "The firſt ſix legs have each a claw; the "other ten have each many crooked ones." This is enough, as to the outward form.

In order to diſcover plainly that a Butterfly is encloſed and hidden in the ſkin of this Caterpillar, the following operation muſt be uſed, One muſt chooſe a full-grown Caterpillar : tie to its body a ſmall thread, and then put it into boiling water, and take it out ſoon after. Thus its external ſkin will ſeparate; becauſe the fluids, between the two ſkins, are by this means rarefied and dilated, and therefore they break and ſeparate both the veſſels and the fibres, wherewith they were united together. By this means the external ſkin of the Caterpillar, being ſpontaneouſly ſeparated, may be eaſily drawn off from the Butterfly, which is contained and folded up in it. This done, it is clearly and diſtinctly ſeen, that, within this ſkin of the Caterpillar, a perfect and real Butterfly was hidden. Therefore the ſkin of the Caterpillar muſt be conſidered only as an outer garment, containing in it parts belonging to the nature of a Butterfly, which have grown under its defence by ſlow degrees, in like manner as in all other ſenſitive bodies that increaſe by accretion.

But as theſe limbs of the Butterfly, which lie under the ſkin of the Caterpillar, cannot, without very great difficulty, be diſcovered in the full-grown Caterpillar, unleſs by a perſon accuſtomed to ſuch experiments, becauſe they are very ſoft, tender, and ſmall, and are moreover complicated or folded together, and encloſed in ſome membranaceous integuments; it is therefore neceſſary to defer the execution of the operation, juſt now propoſed, until the ſeveral parts of the Butterfly become ſomewhat more conſpicuous than at firſt, and are more increaſed and ſwelled under the ſkin, by force of the intruded blood and aqueous humour. This is known to be the caſe, when the Caterpillar ceaſes to eat, and its ſkin on each ſide of the thorax, near under the head, is then obſerved to be more and more elevated by the increaſing and ſwelling limbs, and ſhews the appearance of two pair of prominent tubercles.

That it may be known at what time the changes in the Caterpillar comes on, exactly and regularly, I ſhall proceed to explain the fourth figure, N°. IV. This deſign exhibits the Caterpillar ſwoln, *a b*, all about the ſecond and third rings of the body; whilſt, in the mean time, the reſt, that is, the lower part of the body and the tail, are conſiderably diminiſhed and contracted, *c*. This is the beſt ſtate in which to ſkin the Caterpillar, which I would have well obſerved; for it is for this reaſon only I have ſaid before, that, in order to make the intended experiments, one muſt chuſe a Caterpillar when near the time of changing its ſkin: ſuch is that which I delineate in this figure.

To explain in a clearer method this fundamental propoſition, that the Butterfly is contained in the Caterpillar; or, otherwiſe, that the Caterpillar is the Butterfly itſelf; we muſt carefully obſerve, that after all the limbs of the Butterfly are ſufficiently increaſed within the external ſkin of the Caterpillar, wherewith they are yet kept inveſted, the Caterpillar at length, when about to undergo its change, betakes itſelf to ſome retired place, in which it may ſecurely caſt off its outward ſkin. With this deſign the Caterpillar firſt fixes itſelf, by only a thin and ſlight web, to a board, tree, plant, wall, beam, N°. IV. *dd*, or any other ſolid ſubſtance; and after this, fixing the claws of its two hinder legs in this web, *e*, it immediately ſpins very carefully a ſtrong double thread, or ligament, which it draws acroſs its back, and faſtens it with the former ſuperficial web againſt the beam or wall in two diſtinct places, *ff*: ſo that the fore-part of the Caterpillar's body hangs in this ligament as in a wreath; whilſt, in the mean time, the hinder part lies fixed in the ſuperficial web, faſtened to the beam.

In conſidering this Caterpillar, it muſt be carefully obſerved, that it lays the ſaid wreath ſomewhat obliquely, and about the fore-part of its body. And hence it happens, that when the ſkin of this Caterpillar, lying under this wreath, is turned back and caſt off, the wreath itſelf is not thruſted more towards the hinder parts than to the middle of the body; it being there faſtened a little to the ſoft ſkin, and dried. Hence this remarkable advantage ariſes to the Caterpillar, when ſtript of its ſkin, that it hangs, as it were, in equilibrio. The Caterpillar, having thus diſpoſed all theſe matters with this appearance of judgment and diſcretion, is obſerved to ceaſe all action and motion of its limbs, and to compoſe itſelf in the moſt profound reſt.

Immediately afterwards, or within the ſpace of twenty-four hours, about the fore-part of the head, it may be obſerved, that its limbs, being now fully enlarged under the ſkin, begin, by the very ſlow and gentle tranſportation and appulſe of the blood and humours, to be diſtended, extended, and inflated in ſuch a manner, as to ſwell even beyond the level of the ſkin, and, by thus raiſing the ſkin, it ſtretches it, and makes it ſhine. On the other hand, it is obſerved, that, at the ſame time, the hinder parts of the Caterpillar's body decreaſe in ſize in their turn, in the ſame meaſure, and exactly in equal proportion, and become regularly ſo much ſmaller. Hence all power of motion is immediately taken away from the ſixteen legs of the Caterpillar, ſo that it can afterwards neither creep nor ſtand.

At length this inflation or ſwelling of the limbs, and other parts, which are at this time forming themſelves, and, as it were, budding out into a Chryſalis, proceeds ſo far, that the external skin opens on the back, and afterwards in three diſtinct places in the head, and begins to be drawn off, and rolled away from the fore towards the hinder end of the body: and, by this means, all the limbs encloſed within preſent themſelves to view. Theſe limbs and parts, being then diſpoſed, according to a certain neceſſary order, and unchangeable rule of nature, the creature aſſumes the form of a Chryſalis, repreſented under No. V. This Chryſalis is an inſect without motion; and indeed it cannot be otherwiſe, for its limbs are all incapable of motion: this is neceſſarily occaſioned by the impelled blood, and other humours, diſtending them: add to this, that the limbs are drawn downwards by the ſeparating skin, and a great part of them likewiſe are extended. Nor indeed is this skin drawn off eaſily; nay, not without great labour and difficulty: for all the complications of fibres, by which the upper is joined to the under skin, are then broken. For this reaſon alſo, the Caterpillar draws itſelf at that time one way and another, with an undulatory motion, and by the tremulous palpitation of the rings of its body. By this violence, at length, a limpid kind of ichor or humour is diffuſed between theſe two skins, and the Caterpillar then, at length, caſts off the the old one. This proceſs is perfected very expeditiouſly, after the opening is made in the ſkull. Thus I have briefly, but exactly, deſcribed how this Caterpillar aſſumes the form of a Chryſalis; the ſeveral parts of which are however ſeen with greater difficulty, than thoſe of the Nymph.

On the other hand, when this Chryſalis, or rather, to ſpeak properly, the involved Butterfly, is drawn out of its ſkin, by means of hot water, it has a quite different form, as may be ſeen in Figure II. where it is repreſented laid on its belly: and this is yet more perfectly illuſtrated in Fig. III. which preſents it lying on its back, ſhewing thus all its limbs. But becauſe theſe delicate parts cannot be ſo well diſtinguiſhed by thoſe who are unaccuſtomed to ſuch reſearches, in order to repreſent them the more plainly, I have delineated them, and marked them with diſtinct letters in Fig. IV. It may eaſily be obſerved there, how that Butterfly, which I have drawn out from the ſkin of the Caterpillar, is provided with all thoſe members, which are ſeen in the Butterfly, delineated in No. VI. As the two horns on the head, *a a*; the double curled proboſcis or trunk, placed in the lower part of the head, between the horns, *b*; and four wings ſituated on the two ſides of the thorax, *c c*; between which are likewiſe ſeen ſix legs; and laſtly, the abdomen divided by its annular ſections, *d d*. All theſe things appear ſo clearly and diſtinctly to the eye, in a natural example, that there is not the leaſt room to doubt the truth of the fact. This is the very creature intimated in No. V. and called in that ſtate an Aurelia, or a Chryſalis; tho' it ſcarce expoſes to our view any parts, which agree with the creature of the fourth Figure: yet it has no other than the ſame limbs and parts, only they are diſpoſed in a different manner, as I ſhall explain hereafter. It will then likewiſe appear that thoſe, which I repreſent ſeverally in this Tab. XXXVII. are all but one and the ſame creature, only hidden, as it were, under different forms; and this is likewiſe the caſe in man, if we conſider the original egg, with its coverings, the navel ſtring, and its ſeveral changes; as I ſhall explain at large hereafter.

To ſhew moſt diſtinctly the difference between the Butterfly drawn out of the ſkin of the Caterpillar, and repreſented in Fig. III. and the ſame Butterfly, when called a Chryſalis, or Aurelia, as delineated in No. V. It muſt be obſerved, that the real difference conſiſts only in this, that the limbs, that is the legs, wings, &c. are ranged and diſpoſed in the Chryſalis, according to a certain order and neceſſary rule; and, on the other hand, that theſe parts are by art rudely unfolded, and turned out in the Butterfly, drawn from the ſkin of the Caterpillar, and removed from their natural ſituation, which they obtain firſt under the ſkin of the Caterpillar, and afterwards in the Chryſalis.

Hence the Chryſalis, No. V. is nothing elſe but the Butterfly expreſſed in Fig. III. the expanded parts of which are folded, and diſpoſed among one another in a different form and order.

It muſt be at the ſame time carefully obſerved, that theſe limbs, and other parts, are found to be of three diſtinct magnitudes: for, in the Caterpillar, No. IV. the limbs are ſtill ſmall, and concealed entirely under the ſkin; and then in the Caterpillar, or Butterfly, ſtripped of its outer ſkin, Fig. III. they are extended much larger; and laſtly, in the Butterfly, under No. VI. they are larger. Yet this obſervation muſt be particularly attended to, becauſe the three creatures, juſt now mentioned, are one and the ſame, and their limbs and parts alſo are the ſame. But as to the larger or ſmaller ſize of them, that depends only on the blood and humours, which being moved in the limbs, has at length extended them as much as poſſible. In the creeping Caterpillar, it was not poſſible for theſe members to increaſe much: and in the full-grown Caterpillar, they could not be produced further than the ſkin was capable of being diſtended: but under the form of a Chryſalis, there has been a conſiderably greater extenſion; ſince the external ſkin is there caſt off, and theſe parts have acquired another form. However, they are not yet arrived to their full ſize; ſince the laſt ſkin, which the Chryſalis muſt throw off, could not be extended further than the folds and wrinkles, into which it was contracted, could give way by unfolding or diſplaying themſelves. It happens in this ſtate, that the creature neceſſarily wants all that motion, which it had before under the form of a Caterpillar, and muſt reſt for ſome days, until the blood and humours, with which its limbs were filled and diſtended, are diſſipated ſufficiently by means of an inſenſible evaporation; and then the faculty of moving is reſtored to it.

Hence, therefore, it is certainly and clearly evident, that one animal is here, as it were, hidden or encloſed in another: nay, that the Caterpillar and Chryſalis are the Butterfly itſelf, but encloſed or covered by an hairy and cutaneous coat; and ſo altered by the different diſpoſition of the parts, that it cannot yet be known. This is the fact which I propoſed to demonſtrate. And nothing further now remains, but to deſcribe the diſpoſition of the limbs under the ſkin of the Caterpillar, No. IV. for which purpoſe, I muſt compare thoſe parts one with another, as they are conſtituted in the Chryſalis, under No. V. for thus it will be evident, how the members of the Butterfly, drawn out of its ſkin, are diſpoſed as well in the Caterpillar, as in its Chryſalis.

As therefore the diſpoſition and arrangement of the parts in the Butterfly-Chryſalis, is found, in No. V. to be worthy of the greateſt admiration, I ſhall obſerve, that theſe ſame parts are not leſs admirably diſpoſed in the Butterfly, when drawn out of its ſkin, Fig. IV. this perfect animal being at all times hidden and encloſed in the Caterpillar, No. IV. The legs, which in the Butterfly, at the time it lies in the Chryſalis-ſtate, are ſtretched between the horns, and placed on either ſide in the breaſt near the trunk, are in the Caterpillar ſomewhat curled and complicated under the ſkin of the ſix fore-feet of that creature: for, as the impelled blood could not equally extend them in that part; they therefore appear there ſomewhat wrinkled and inflected: that continues until the ſkins are at length caſt off, and they are again extended as much as poſſible, in the Butterfly-Chryſalis; and whilſt the ſkin is outwardly drying, they are joined one with another.

The wings, which in the Chryſalis-Butterfly, are evidently extended in each ſide of the breaſt near the horns, are placed under the ſkin of the Caterpillar, near the under legs of the firſt claſs; nay, their ends are encloſed in the ſkin of the ſame legs. This ought to be carefully obſerved; ſince this is the only reaſon why, when the Caterpillar is changed into a Chryſalis, the limbs are neceſſarily thus, and not otherwiſe, diſpoſed: for theſe legs and wings are, at the time the old ſkin is caſting off, drawn downwards, together with the ſkin in which they lie, and are then regularly diſpoſed on the breaſt, near to and between each other: and this is performed with ſuch great art, and in a manner ſo ſingular, that this ſubject only, might ſupply matter for a whole treatiſe.

The horns, which in the ſtripped Butterfly, that is already changed into a Chryſalis, are extended and ſituated between the legs and wings on each ſide on the breaſt, ſo as to touch at the ſame time the trunk with their extremities, are, in the Caterpillar, hidden under that part of the head which conſtitutes the ſkull; and theſe thruſting themſelves up out of the head, are very cloſely folded together, and, by a particular convolution afterwards, repreſent a ſerpentine winding. Their extremities are likewiſe cloſely twiſted into one. Hence the horns in the Chryſalis could be extended above the breaſt, on the caſting of the ſkin. This I have already, with reſpect to the Chryſalis of the coloured Butterfly, more accurately demonſtrated, magnified in the explanation of Tab. XXXV. It will be proper to compare this hiſtory with that, and to read them together, becauſe the one throws great light upon the other.

The trunk, which, in the Butterfly ſtripped of its ſkin, and changed to a Chryſalis, is ſtretched along, and ſituated on the middle of the breaſt between the legs, horns, and wings, is found to lie wonderfully complicated, under the ſkin of the creeping Caterpillar, between ſome briſtly and articulated hairs, ſituated near the lower part of the mouth. Theſe very briſtly hairs, and the trunk, are alſo found regularly diſpoſed in their reſpective places in the Aurelia, after changing the ſkin.

Laſtly, the belly and tail, which in the Butterfly, when it repreſents, Tab. XXXVII. No. V. a Chryſalis, are found ſhortly contracted and drawn together, are in the Caterpillar, No. IV. extended through the greateſt part of the ſkin of the body. In the hidden Butterfly, or creeping Caterpillar, No. III. all that part of the body chiefly, which is extended from the fore-legs to the hinder extremity, muſt be accounted the belly and tail; and at the time this creature is changed into a Chryſalis, it loſes all its ten hinder legs, without exception.

But, as it is not enough for me to have exhibited and deſcribed the moſt profound myſteries of nature, as I have done hitherto; ſo, at the ſame time, I think myſelf obliged to communicate to the reader, the management by which I was enabled to find out in the hidden Butterfly, the diſpoſition of its limbs under the ſkin of the Caterpillar: ſince theſe limbs are there ſoft, tender, and almoſt fluid like water; and therefore, when any one draws off the ſkin from them, they are moſt eaſily removed from their natural ſituation.

In order therefore to provide againſt this, and that the parts of the Butterfly, Fig. IV. hitherto deſcribed, which lies under the ſkin of the Caterpillar, No. IV. may be viewed to ſatisfaction, and ſeen as they are naturally diſpoſed, we muſt take care, that theſe parts be firſt hardened under the ſkin, to ſuch a degree, as that they will not loſe their natural ſituation afterwards, when the ſkin is taken therefrom. This is done very conveniently, if a Caterpillar, which is going immediately to caſt its ſkin, be put into a bottle full of a liquor compoſed of equal quantities of ſpirit of wine and vinegar; for, as the Caterpillar is very eaſily killed by this liquor, its limbs alſo will harden therewith, in the ſpace of fifteen or ſixteen hours. Therefore, if the Caterpillar be afterwards carefully ſkined, the diſpoſition, and ſeveral foldings of the limbs of the encloſed Butterfly, may be very beautifully ſeen, as they lie under the ſkin of the Caterpillar.

I ſhall now proceed; and, in order to ſet this matter in the cleareſt light, I ſhall exhibit alſo, by diſtinct letters in Fig. v. all thoſe limbs and parts of the Butterfly which I have demonſtrated in Fig. IV. or thoſe that are already deſcribed in the Chryſalis under N°. V. That is, I ſhall now likewiſe ſhew, in the Chryſalis or Butterfly, which hath ſpontaneouſly changed its ſkin, all the parts which I have before ſhewn in the Butterfly, drawn out of the ſkin of the Caterpillar by art: for the creature, which I repreſent in Tab. XXXVII. Fig. v. is the ſame which I have already delineated under N°. III. In this are firſt ſeen the horns, Fig. v. *a a a a*, diſtorted from their natural ſituation: then are obſerved the two parts of the trunk, which, ariſing below out of the head, and running over the breaſt, are terminated, *b*, on the lower part of the body; where they are likewiſe, but not much, deflected or bent out of their natural ſituation. Next are diſcovered, on each ſide, two legs, which, being removed out of their natural ſituation, I have placed on each ſide of the upper wings, *c c*. The other two legs are not here repreſented, ſince they may be plainly and more eaſily exhibited lying under the trunk and wings in the inſect itſelf, than they can in this figure. Under theſe two pair of legs the upper and lower pair of wings come likewiſe in ſight, though only a part of the lower appears to the eye, *d d*, becauſe they are covered in great part by the upper pair. All theſe four wings are likewiſe drawn out of their ſituation. The head and eyes, *e*, are ſeen above, and the tail and the annular diviſions of the belly below, *f*. However, one can ſee all theſe things but obſcurely, for two reaſons: firſt, becauſe theſe limbs, being placed in this manner in the Chryſalis, are diſpoſed in a peculiar order; and becauſe they are, in that ſtate alſo, grown ſtiff and hard, by the power of the air. But it is eaſy to diſcover the ſame limbs of the Butterfly in all the Aureliæ, and to ſeparate them from each other; provided one has firſt ſteeped them for a little time in hot water.

I ſhall now likewiſe exhibit, in Fig. VI. all the limbs and parts hitherto enumerated, as well of this as of the creatures repreſented above, ſince they are all but one and the ſame creature. There is this difference ſhewn in the preſent figure, that I have ſtript the limbs, which I now preſent to view, of their laſt ſkin, wherein they were kept ſtill rolled up: ſo that we here now view this inſect clad, as it were, in its perfect outſide, which is never caſt off, and is aboliſhed only by death. But as in caſting the laſt ſkin, there is as much art obſerved as in the drawing off of the external skin of the Caterpillar; I ſhall here briefly explain the whole order of this laſt change, or the ſudden ſwelling out of the limbs.

In the VII Figure I exhibit the Butterfly, the limbs of which were before repreſented in the IV Figure, and as having put on the form of a Chryſalis, delineated under No. V. And this Chryſalis being very near its metamorphoſis, is in that ſtate every moment ready to caſt its laſt skin. If any one deſires to know, by what means it can be known, that this change is very near; let him obſerve, that this may be certainly known beforehand by thoſe black ſpots, which are obſerved to appear through the skin of the Chryſalis, at the ends of the two upper wings; and therefore I delineate one of thoſe pellucid ſpots in the left wing of this Butterfly-Chryſalis.

In order to underſtand the method, whereby this laſt change of the skin is performed, it is neceſſary to know, that after the encloſed limbs of the Butterfly, have by degrees acquired their full ſtrength, by the help of an inſenſible perſpiration, it at length, by agitating and moving itſelf, and by drawing its breath with greater force, breaks open the external skin with which it is ſurrounded, in three or four different places, and diſplays looſe and free its hitherto united parts.

When the inveſting skin juſt begins to open, it is obſerved, that the ſtrength of the encloſed Butterfly is likewiſe increaſed. And hence it then immediately thruſts its horny trunk and legs out the skin, and fixing the claws of its feet to the adjacent objects, or to its own caſt skin, it thus, as it were, by force, diſengages itſelf from this laſt covering. Thus at length it creeps out of its skin, formed in the manner exhibited in the ninth Figure. Nor does its appearance then differ much from that which it had, when drawn out of the skin of the Caterpillar by art, as may be ſeen by the Figure.

I deſire leave to obſerve here, that the creature ſcarce retains this form a moment; for as ſoon as the skin is regularly broke open, and the Butterfly juſt begins to creep out of it, immediately its wings begin to increaſe, and they grow wonderfully faſt. Before I treat this matter more fully, I muſt obſerve what I have hinted at in the preceding ſheets; that is, that the limbs, and eſpecially the wings of the Butterfly, are of three diſtinct ſizes: they are ſmalleſt when they lie in the Caterpillar, delineated under No. III. and then in the Butterfly, drawn out of the skin of the Caterpillar, as in Fig. IV. they were obſerved ſomewhat larger; and laſtly, they have acquired their third and full magnitude, when, by the impelled blood and humours, they have been orderly ſituated in the Chryſalis, delineated No. V. But even then, they could not extend themſelves further; becauſe the laſt skin that remained to be caſt off, did not permit it.

Therefore, when theſe laſt skins are caſt off, it is at length ſeen, how theſe wings increaſe, ſwell, and are expanded in a moſt wonderful manner, by the force of the blood, humours, and impelled air: this is exhibited in the X Figure. When any one has for ſome time conſidered this matter in the Butterfly itſelf, he will ſay that it is like a drop of water, which, when it falls on dry paper, dilates the paper, and makes it unequal, thick, and full of holes. In the ſame manner, indeed, theſe wings, which are in the beginning rough and full of wrinkles, and unequal, fold and expand themſelves, until at length they become ſmooth, and they are then twelve time times as large as they were in the beginning. This may be ſeen in No. VI. where I repreſent the wings fully and perfectly expanded, and in their natural ſize.

What deſerves moſt admiration is, that all this accretion of the wings, great as it is, does not take up the ſpace of a quarter of an hour. And beſides, what is very conſiderable is, that if at this time a part of the growing wings be cut off with ſciſſors, they manifeſtly diſcharge blood more or leſs copious, according as the wing is wounded at a leſs or greater diſtance from the body. This blood, which is yellowiſh, diſtils in ſmall globules out of the wounded veſſels, and the wing never afterwards expands itſelf properly. But theſe wings, being once wholly extended and dried, will never afterwards diſcharge any blood, though they be wounded ever ſo often. Hence it is evident, that this creature, in the ſpace of a quarter of an hour, is ſent forth from the Chryſalis in every reſpect perfect *, ſo that it never afterwards wants a further accretion, nor is ſubject to the miſchances of infancy.

In what manner theſe wings are in reality expanded, and how their black ſpots are diffuſed from ſmall into large ones, and how all the colours of theſe wings are increaſed, and are all together equally changed by the ſame motion; theſe, with other innumerable curious and wonderful myſteries of nature, I ſhall, if it pleaſe God, explain hereafter in a treatiſe expreſly on that ſubject: and I ſhall then ſhew how one may view, as clear as the light at noon, the reſurrection of the dead, and the happy ſtate of thoſe that are brought to life again, in this little inſect.

I ſhall finally in this place briefly lay before the eye, the limbs of the Butterfly, and the increaſing wings in a rough draught, and afterwards conclude this hiſtory. Firſt, in the head are ſeen two reticulated eyes. Over theſe are obſerved two horns, Fig. XI. *a a*, divided into their joints, and adorned with white, yellow and blackiſh ſcaly feathers. Between theſe, one may perceive how the Butterfly rolls its trunk, *b*, which it ſome time afterwards hides between the forks. In the thorax, the two upper wings *c c* preſent themſelves, which are almoſt every where covered with white little feathers, and in ſeveral places are variegated with thinner, feather-like yellow ſcales: even the black ſpots, which adorn their extremities, are compoſed of ſimilar ſmall feathers. The ſame likewiſe is the condition of the two under wings, *d d*. Six legs likewiſe appear, *e e e e*, which are increaſed to a much greater length than they had either in the Caterpillar, or in the Butterfly, drawn out of that skin: but in this laſt change of the skin, the legs are increaſed no more; ſince they have already acquired their full bigneſs in the Chryſalis. Laſtly, the tail and abdomen are ſeen covered with their rings, hairs and feathers, *f*. It is likewiſe obſervable, that all theſe colours may be wiped off the wings in ſuch a manner, that only a thin, delicate, and tranſparent membrane remains. And now, can any perſon, who rightly conſiders theſe divine miracles, help admiring them, and agreeing, that they are moſt truly ſuch? Indeed this remarkable hiſtory very ſtrongly evinces, that the moſt wiſe and merciful God, is manifeſtly known from his viſible works: ſince thoſe inſtances of this power which are remote from our ſight, become evident from thoſe we ſee; that the eternal nature of God is therein diſplayed clearer than the meridian ſun. Their offence therefore is inexcuſable, who have either lived inſtructed by the law of nature only, or have known the law of Moſes, and the goſpel of Chriſt; for, according to theſe, all men ſhall be judged, and ſhall be either abſolved or condemned.

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* The whole operation in the diſcloſure of the Butterfly from its Chryſalis, is full of wonder; but in no part ſo much as in the expanſion of the wings. From the folded and complicated ſtate wherein they lay in the Chryſalis, they diſplay themſelves ſo ſuddenly, that the firſt obſervers thought they were ſmall at that time, and grew thus ſuddenly. The ſubſtance of theſe wings is membranaceous, and the duſt which covers them is compoſed of regular little parts, called by ſome feathers, and by others ſcales; but neither properly. They have footſtalks, and they are of various figures, oval, round, oblong, and indented. On theſe depend the colours of the wings. The veſſels which ſupport the filmy ſubſtance of the wing, contract as ſoon as the wing is expanded; for, till then, they are tubular. They are like the navel-ſtring in the human body; at firſt vaſcular, but afterwards ſolid. The edges of the wings are ſupported by a ſtrong rib, and fringed with theſe feathery ſubſtances.

The FOURTH ORDER.

Of natural changes, or ſlow accretions of the limbs.

HAVING now explained the more ſimple and intelligible modes or methods of theſe changes, I ſhall proceed to the compound, and more obſcure, which ſeem indeed wholly incomprehenſible; but in reality, all the inſects of this fourth order, of which I am now to treat, the changes of which I have hitherto obſerved, are changed into real Nymphs, entirely like thoſe of the firſt ſpecies or method of the third order. Therefore we may refer all the Nymphs belonging to this fourth order, to the Nymphs of the firſt mode of the third order: for though the Nymph of the fourth order, does not ſo clearly exhibit its limbs to view, as that of the firſt and ſecond order; yet they are more diſtinctly viſible, than in the Chryſalis belonging to the latter mode of the third order. Hence this Nymph muſt be rightly and properly reckoned among thoſe, which I have delineated and deſcribed under the firſt method of the third order; ſince the former exhibits its limbs as clearly as the latter.

To thoſe who examine this Nymph more accurately, there likewiſe occurs a conſiderable and important difference, which conſiſts in this, that this creature does not caſt its skin, but is changed within it, and without parting with it, into a Nymph. Hence it is, that on account of this difficulty of diſtinguiſhing the parts of this Nymph, I am obliged to add a fourth order, to comprehend this peculiar kind; though in reality the intrinſic Nymph of this fourth order, is exactly like the external Nymph of the third order, and is of the ſame nature and diſpoſition with the latter, without any difference.

In order to place this matter in as a clear a light as poſſible, it is neceſſary to obſerve carefully, that even in the worms, which undergo the changes of this fourth order, the limbs increaſe ſlowly under the skin, in the ſame manner as in the already mentioned Nymphs of the third order; and are there diſpoſed in like manner and order under the skin, as they are found arranged under it, in the Vermicles or Worms of the third order; but there is, however, a conſiderable difference, by which, as by a criterion, or certain ſign, one may diſtinguiſh theſe two Nymphs of the different orders from each other. It conſiſts in this, that the Nymphs of the fourth order do not at all exhibit to view their limbs, nor make them viſible at any time: for, as the Vermicles, or Worms, which are changed into Nymphs of the third order, caſt their skins, and afterwards preſent to outward view all their limbs and parts, which had been before hidden under them; on the other hand, the Vermicles or Worms belonging to this fourth order, do not caſt, but retain the ſaid skin. And hence, as the Nymphs of the third order, when they are afterwards about to put on the form of real Nymphs, caſt only one skin; theſe interior Nymphs of our preſent fourth order, at the ſame time caſt off two skins or membranes, whereof the outer is much thicker than the inner. This is what conſtitutes the eſſential difference I have named, between the Nymphs of the third and thoſe of the fourth order, which are perfectly alike in all other reſpects.

It is very wonderful here, that ſome of the Vermicles, or Worms, which are referred to our fourth order of changes, preſerve their original and external form entirely unaltered; whilſt, on the other hand, others in great part loſe it. But theſe, though they do thus far deviate from them, yet they never entirely loſe all the marks of the former Vermicles, or Worms; for they retain, as it were, the figure of Vermicles, or Worms: and in this very figure, or, to ſpeak more forcibly, in their proper ſkin, which they do not caſt off, they become immoveable; and there ſhooting out new limbs, they at length put on the form of real

Nymphs, within their uncaſt ſkin. And this change is, therefore, almoſt like that undergone by the Vermicle, or Caterpillar, which is changed hidden within its web, and out of ſight, as is properly and truly alledged by Mr. Ray. Vid. Catalog. Plant. circa Cantabr. naſcent, P. 137.

Since, therefore, the Worm either retains its own proper figure entirely, or deviates a little from it; but which ever of the two forms it puts on, yet always increaſes into a Nymph within its uncaſt ſkin. Hence it is, that I think it very reaſonable to denominate this change by the appoſite appellation of a Nymph-Vermicle; for the Worm, having ſtill retained its outer form, acquires the true nature of a Nymph in its uncaſt ſkin. Before I further explain in what manner theſe worms, which either retain their form or partly loſe it, are conſtructed internally, I ſhall offer ſome general obſervations on the eggs, ſmall animals, Worms, and Nymphs in each of the four orders, and compare all thoſe proceedings of nature together. This, indeed, will contribute greatly to the underſtanding of this our fourth order.

With reſpect to the eggs of the Inſects in the firſt order, it muſt be obſerved, that the ſmall animals encloſed in them are like the Nymphs of the fourth order; and are ſurrounded or covered with their regular inveſting ſkin, in the ſame manner as the Nymphs of that order are involved in the ſkin of their Worms: ſo that, by reaſon of this integument, one can by no means diſtinguiſh the ſeveral parts. But the Inſects of the firſt order, without any intermediate change, directly iſſue perfect out of the ſhells of their eggs; nor are they cloathed like Worms firſt, nor do they attain the full term of their increaſe before they are hatched. And hence it is, that they are not afterwards changed into immoveable Nymphs, but only caſt their laſt ſkin: and it is therefore for this reaſon I call this change, at that time, a Nymph-Animal.

Moreover, in regard to the eggs of the ſecond order, it muſt be obſerved, that the Worms contained in them are likewiſe inveſted with ſuch a ſkin as thoſe of the firſt order, and that there are likewiſe properly Nymphs in it; but they iſſue from thence imperfect, in reſpect to all their limbs and parts, which afterwards inſenſibly increaſe externally in their body: and, for this reaſon, the Worm precedes that change of them, which I call the Nymph-Animal. And hence this ſecond order conſiderably differs from the firſt, in which the animal iſſues perfect out of its egg. But theſe two orders agree alſo in this, that, in both of them, the animal increaſes into a Nymph, whilſt it is moving and walking about; and this Nymph alſo is, without loſing its motion, at laſt changed, and it caſts a ſkin.

The eggs of Inſects of the third order are likewiſe inviſible Nymphs, which are placed there without food: ſo that, in this reſpect, all theſe three ſpecies of eggs agree. But the Worms, which, in this third order, creep out of the eggs, differ ſtill more, in regard to the perfection of their parts, from the Worms of the ſecond, than thoſe of the ſecond order do from the ſmall Animals of the firſt. For all the limbs of the ſmall Animals of the third order do not grow out of the ſkin, but, in a concealed manner, under the ſkin; for which reaſon they are removed from our ſight, until at length the creatures, having caſt their ſkin, and changed their original form, preſent all theſe things to view externally. Beſides, about this time, theſe Inſects entirely loſe all motion; and then put on a-new the ſame habit which they had before in the egg. This change I call the Nymph and Chryſalis, as being a third ſpecies, different from the firſt and ſecond order. However, all theſe three orders reſemble each other in this, that the eggs of each are Nymphs at firſt: and the ſecond order yet ſpecifically anſwers to the third in this, that, in each of them, the change into a Nymph is preceded by a Worm or Caterpillar.

Laſtly, the Worms of the fourth order are, in their eggs, likewiſe plainly Nymphs, whoſe limbs and other parts are ſo involved in the ſhells of the egg, that they can by no means be diſtinguiſhed: wherefore thoſe Worms thus far agree with the eggs of the firſt, ſecond, and third order. But theſe differ from the little creatures which iſſue from the eggs of the firſt order, in that they break, as imperfect Vermicles or Worms, out of their eggs. They likewiſe deviate from the Worms of the ſecond order, in that their limbs do not grow externally, but within their ſkin: and, in this reſpect, they again exactly anſwer to the Worms and Caterpillars of the third order. However, they differ alſo from thoſe of the third order, in that they never preſent their limbs, in this ſtate, to outward view; but are changed into Nymphs within their ſkin, which they never caſt off, but become immoveable therein. By this means they, in reality, aſſume a ſecond time that form which they before had in their eggs; and therefore I call this change the Nymph-Vermiform, as being entirely different from that of the walking Nymphs in the firſt and ſecond order: though, with reſpect to all the parts, it anſwers to the Nymph of the third order, only that it is inviſible. It agrees likewiſe with the ſecond and third order, in that the Worm precedes the final change: whereas, on the contrary, there iſſue out of the eggs of the firſt order of Inſects creatures like their parents, nor does the Worm-ſtate precede their Nymphs.

This matter being underſtood, it is clearer than the light at noon, how far thoſe eggs, ſmall Animals, Worms, and Nymphs of the firſt, ſecond, third, and fourth orders agree, and in what they diſagree one from another; and alſo what is accidental, as it is called, in each, and what is eſſential to their ſeveral natures. Indeed, when theſe things are rightly obſerved, there is nothing in our fourth order of tranſmutations which may not be clearly and eaſily underſtood; ſince the whole conſiſts in this, that the Nymph remains hidden under its ſkin, which it never caſts; nor does it even, at any time, preſent itſelf externally to view: that is, this Nymph lies hid in its Nymph, in the ſame manner as the little creature of the firſt order does in its egg, in which it is likewiſe an inviſible Nymph; or as the Worms of the ſecond and third order, which are likewiſe inviſible Nymphs in their eggs; or, laſtly, as the Worm of this fourth order, which is likewiſe an inviſible Nymph, while in its egg. The eggs of all the four orders entirely agree, in general and in particular, with the change of the Worm of our fourth order into a Vermiform Nymph.

Having conſidered ſufficiently what has been ſaid, I ſhall proceed to explain how it happens that the Worms, belonging to this fourth order of changes, do more or leſs deviate from the original form of the Worms, though they do not by any means caſt their ſkin. In order to explain this clearly and diſtinctly, I muſt firſt obſerve, that ſome of the Worms which belong to the fourth order of changes, are provided with hard, tenacious, and ſtrong ſkins; and others, on the contrary, have thin, ſoft, and flexible ſkins. This diverſity of ſkin not only makes the tranſmutation of form more or leſs remarkable, but renders it ſo obſcured in the Worms inveſted with a ſoft ſkin, that it becomes entirely incomprehenſible and inextricable. On the other hand, when the Worms are covered with a hard ſkin, we ſee nothing of this kind happens; for as their external tenacious ſkin cannot form and accommodate itſelf to the internal change, which the body of the encloſed Nymph undergoes, that ſkin neceſſarily retains the figure of a Worm, and reſembles it as exactly as if it were ſtill alive.

When the Worms, which I have referred to the firſt ſpecies or method of the fourth order of changes, have eaten ſufficiently, and their limbs are increaſed to the proper degree under the ſkin, they ſeek a proper place for themſelves, wherein they may ſafely and quietly iſſue into a Nymph. After this they reſt for ſome time, until they inſenſibly loſe all their former motion. But they are not even then conſiderably contracted, nor do they become ſmaller, or are they changed in form; though, in the mean time, they put on the form of a real Nymph within their uncaſt ſkin.

Hence, therefore, we draw this important concluſion, that the inſenſible perſpiration, which I have aſſerted to obtain univerſally in the Nymph, may, in this example, be ſeen, as it were, with our eyes: for, in the Worms of this firſt ſpecies, it is obſerved, that the Nymph fills the whole ſkin of the Worm. But this Nymph afterwards, changing colour in a manner not perceivable by the ſenſes, and contracting itſelf by degrees, inwardly recedes on each ſide from the extreme ends of the ſkin, and conſequently then fills only a part of it. And this proceſs continues, until the Nymph, being more and more contracted, by reaſon of the evaporation of the ſuperfluous humours, manifeſtly forms in the uncaſt ſkin of the Worm two very conſpicuous cavities, one towards the head, and the other towards the tail and belly of the ſaid Nymph; and theſe cavities become afterwards larger and larger, until the creature has acquired its perfect ſtrength. The very experienced Dr. Harvey. has obſerved ſomething like this, concerning the little cavity in hens new-laid eggs; for this alſo is inſenſibly inlarged afterwards, by the evaporation of the fluids.

Wherefore, when the ſkin is hard and tough in theſe Worms, or when it grows ſomewhat hard at the time the Worm is inwardly obtaining the form of a Nymph, the former figure of the Worm muſt neceſſarily remain entire: whilſt, in the mean time, the little creature puts on the form of the Nymph within the hardened ſkin, from which it is more and more inſenſibly ſeparating; as I ſhall afterwards very clearly demonſtrate, in the figures of my fourth order. The ſeveral obſervations which I ſhall ſubjoin to theſe, will indeed render this matter yet more clear and intelligible; for I preſume boldly to appeal to thoſe obſervations particularly, ſince I have employed thereon all the induſtry I was capable of.

As to the ſecond method of the changes in this fourth order, it comprehends thoſe Worms which are covered with a ſoft ſkin; and it offers one thing to be conſidered particularly, which is, that the external ſkin accommodates itſelf to the body of the Nymph which is inwardly changed. But becauſe this internal tranſmutation of the little Body or Nymph becomes of the ſhape of an egg, in many ſpecies of theſe Vermiform-Nymphs, therefore the external ſkin alſo, which is not caſt off, then neceſſarily acquires an egg-like figure. By this means theſe Worms alſo are changed into ſuch Nymphs as do not caſt their ſkin. The Nymphs, which are ſubject to this method, are very complicated and difficult to be known, beyond all the reſt of the fourth order, as their Worms have a very delicate and tender ſkin. Theſe Nymphs, for that reaſon, recede leſs from the form of their Worms than thoſe in which their ſkin is ſomewhat thicker; ſo that the hardneſs or thickneſs of the ſkin makes the change plainer, or more obſcure to us.

However widely theſe Nymphs differ from the prior form of their Worms, they all preſerve various traces of that form. In the firſt place, they retain the ſkin uncaſt; and the annular inciſions, the head, tail, and the reſt, are preſerved or altered, according as they more or leſs deviate from the form of Worms. Some alſo have appearances like legs, horns, and other marks. For theſe important reaſons, I give them all promiſcuouſly the name of Vermiform-Nymphs; though I very well know that they have been called eggs by ſome induſtrious ſearchers into nature, as Mouffet, Goedaert, the illuſtrious Mr. Ray, and lately by the very learned Francis Redi, as if no diſtinct limbs could be obſerved in them. But are not theſe the very Worms themſelves, which have within that skin ſprung up, or budded into Nymphs, by means of the accretion of the limbs? For what reaſon then, or with what right, can we call them eggs? But, beſides all this, the gentlemen now mentioned do not conſider theſe eggs as real animals, but only as ſhells filled with a liquid, out of which the animals are at length to be generated by a ſtrange and miraculous transformation. Hence we alſo obſerve, that Mr. Ray alſo, in his catalogue of the Cambridge plants, with great reaſon doubts, whether the Chryſalis be hidden in the egg which they ſpeak of; at the ſame time confeſſing, that they want a proper word to expreſs this transformation. As this author aſſerts a little before, that theſe eggs have the ſame relation to the Flies as the Aurelia have to Butterflies, he certainly commits a great error: for the Aurelia is the inſect itſelf; but theſe eggs, as they are called, are only the Worm's skins unſeparated, in which is contained not a Chryſalis, but a real Nymph; which clearly and diſtinctly repreſents to the life all its limbs, as may at any time be demonſtrated by us. To this we are to add, that there is no total tranformation in this egg, as they imagine to be the caſe in the Chryſallides. However, it is ſufficient for me to have ſet forth the matter as it is: for I would by no means enter into diſputes about words, but would give each its natural ſignification, provided the eggs, as they are called, be referred to the fourth order of diſagreeing tranſmutations, which is the moſt worthy of notice in all nature; for in this proper diſtribution of things conſiſts the great utility of the preſent work.

In proceeding to elucidate this obſcure order of changes ſomewhat more, I muſt repeat, that theſe Worms, which undergo this particular change, do not put off, but abſolutely retain, their skin, under which their limbs are inſenſibly increaſed and brought to perfection; and therefore, if that skin be tender, it accommodates and contracts itſelf to the figure of the encloſed Nymph. For the ſame reaſon alſo, as the old skin is preſerved, the original rings, which, like ſo many ſmall joints, divide the body of the Worm, may be then ſtill ſeen therein; though, in the mean time, theſe inciſions or rings, in ſome caſes, appear to be obliterated, or nearly ſo, in the skin. This holds chiefly, when the inciſions either have not been very diſtinct in the Worm itſelf, or when a very thin skin, every where entirely obedient to the inwardly hidden Nymph, is ſo extended therewith, that the inciſions or inflexions of the body cannot be any longer known. This I have exemplified in Tab. XLV. Fig. XXVII. and XXVIII.

I have obſerved alſo, that the skin, which is not caſt off, in ſome of theſe eggs, as they are called, has been ſo accurately fitted and accommodated, all about the body of the Nymphs contained within, that it diſtinctly and externally repreſented the three principal diviſions of the body; that is, the head, thorax, and belly. And hence it is, that ſome of theſe Nymphs are obſerved to be, as it were, annulated; and others are without rings. This has likewiſe been partly obſerved by the before celebrated ſagacious gentleman. Thus I have briefly explained all thoſe things which I thought neceſſary to be taken notice of, before I undertook to define this fourth order.

I now therefore proceed, and ſhall direct all my labour to make manifeſt, as clearly as I can, the ſtupendous works of the moſt adored and all-wiſe Creator, which have been hitherto, to our ſhame, but little known; that we may therefore love God, our Creator, with the greater and more ardent zeal, and behold him with higher veneration. We can neither juſtly love or reverence God, ſo long as we are darkened with our ignorance. Let us, therefore, give praiſe and thanks to the Supreme Architect for his unmerited favour, ſince he alone has lighted, and laid before us, the cleareſt fire in all nature: a light, which has not only eaſily diſcovered his moſt wiſe providence and infinite power, in thoſe wonderful means which he makes uſe of to defend and preſerve thoſe things which he created; but has alſo produced thoſe things ſo openly to the view of all men, that its ſplendour cannot be obſcured by any laboured arguments of human origin. We thus ſee, indeed, no more than the ſurface, or, as it were, the ſhadow of the wonderful works of God delineated here, or by any other. And this ought, indeed, to be the greateſt encouragement to us, that we may indefatigably exert ourſelves in theſe reſearches, and rather ſeek for the cauſes and effects of things in nature herſelf than in our ſtudies. Indeed, moſt people are at this time ſo blind, that they imagine no truth ariſes from any other ſource than out of their reaſonings; to which they contend, place ſhould be given as to matters which ſurpaſs even nature. Indeed, we cannot know natural things but by their effects, being incapable of comprehending their cauſes.

Let us return now to what we propoſed; and let it be obſerved, that our fourth order of changes conſiſts only in this, that the Worm, having quitted its firſt form, which it had in its egg, wherein it lay, like a Nymph, without food, inſenſibly acquires, by force of the aliment it is afterwards ſupplied with, other limbs and parts, ariſing by accretion under its skin; and afterwards, at length, in this its skin, which is never caſt off by it, as it is by other creatures that are changed into Nymphs, it aſſumes the form of a ſecond Nymph, and for the firſt time loſes, as it were, all its motion. This, however, is in a few days reſtored to it, by the evaporation of the ſuperfluous humours: ſo that the Worm, then laſtly diſengaging itſelf from theſe skins, caſt two skins together; and now diſplaying itſelf with pride, in a more elegant garb, and become mature, as it were, for propagation, it immediately ſhews itſelf ready to perform this, the great buſineſs of its life.

A catalogue of the inſects referred to the fourth order or claſs of natural changes, which we call the Vermiform Nymph.

AFTER having ſet forth, with all the perſpicuity and diſtinction I have been able, the four orders of changes which I have eſtabliſhed, and before enumerated the inſects of the ſecond and third order, I now proceed to recount thoſe creatures which I obſerve to belong to the fourth. A great number of theſe I have preſerved in my Muſeum.

Firſt, I refer to this fourth order the eggs of inſects in general: not only thoſe, which produce a perfect creature according to the firſt order, and thoſe which, in the ſecond order, contain a Worm; but alſo thoſe which, in the third and fourth orders, produce a Worm or Caterpillar. For I obſerve, that all theſe creatures and the Worms are diſpoſed in their eggs and skins, nearly in the ſame manner as I have ſaid the Nymph of the fourth order, a little before deſcribed, is in its uncaſt skin. Even thoſe little creatures, which iſſue perfect or imperfect out of their eggs or ſhells, caſt two skins at the ſame time: and this has appeared to me very evidently in ſome; nay, I can ſeparate even the external from the internal in ſome of them, as I ſhall ſhew hereafter in my figures. From this the reaſon is evident, why I ſay that theſe inſects lie in their eggs like Nymphs, and are as much removed from our view as the Nymphs of our fourth order, juſt now deſcribed; that is, as I have already obſerved, the external skin, in each caſe, prevents the Nymph from being ſeen and known.

Of thoſe eggs, which, in my firſt order or claſs of changes, I called Oviform-Nymph-Animals, and, in the ſecond, third, and fourth orders, Oviform-Nymph Vermicles; I preſerve a great many ſpecies, vaſtly different from each other, not only in ſhape, ſize, and colour, but in their origin likewiſe, being, as I have already obſerved, the produce of different inſects. Particularly, there are in my collection ſome very minute Flies, immediately ſprung from the eggs, which the Moths faſten with a kind of glue round the branches of trees, in form of a ring. Hence it plainly appears, that the eggs of ſuch inſects belong to the firſt mode or method of the fourth order.

Having ſaid thus much of eggs in general, I now, in the ſecond place, and in a more particular manner, refer the Worms found in our privies, or neceſſary-houſes, to the ſame order, and the ſame mode of change, as, on their alteration to Vermiform-Nymphs, they loſe nothing of their original ſhape; but are only covered with a hard and ſtubborn skin. I can produce that ſpecies of thoſe Worms, and of their Vermiform-Nymphs, from which the common Flies of neceſſary-houſes proceed; and have therefore given, in the XXXVIIIth Table, drawings of this inſect in the Worm, Nymph, and Fly-ſtate, beſides one of its eggs, which are very remarkable, drawn from a ſpecimen I keep amongſt my other curioſities of this kind.

Thirdly, I place in this order the Vermiform-Nymph of the Gadfly, as it perfectly retains the form it wore in the Worm-ſtate. The XXXIXth, XLth, XLIſt, and XLIId Tables, with their explanations, give a ſatisfactory account of every thing for which this inſect is particularly remarkable, in diſpoſition, ſhape, and changes from a Worm to a Fly; including the figures of the apparent Nymph, and that of the real Nymph, which the apparent Nymph includes. This Fly, as Ariſtotle rightly obſerves, proceeds from a kind of broad and flat water Worm; the ſame with thoſe inſects which Aldrovandus, without knowing that they produced the Gadfly, has deſcribed by the name of Water-worms, or Inteſtines. I preſerve four ſpecies of this Worm, with the Flies to which they change; as likewiſe an apparent Vermiform, or worm-like Nymph, of a very ſingular ſhape, and the real Nymph, extracted by diſſection from the inſect in that motionleſs condition. I have frequently met with this kind of Fly, about the end of ſummer, in the flowers of the garden-parſnep; though, at the time when I formerly made my ſelect obſervations, I could not diſcover what their food was.

I likewiſe reckon of this order the Vermiform, or worm-like Nymph of the Tabanus, or Breezefly; though I am, as yet, at a loſs for its * origin: but I have great reaſon to believe, that the manner of its becoming a Fly is the ſame with that of the Aſilus, or Gadfly. It is very remarkable, that nature has given theſe inſects an aculeus, or ſting, as well as a trunk; ſo that they may either make uſe of the trunk to procure the honey, dew, and other juices which ſpontaneouſly offer themſelves upon plants and flowers; or of the aculeus, or ſting, to ſuck blood of ſuch creatures as they are obliged to kill or wound to feed upon. How admirable the mercy of their Great Parent, in having ſupplied them with this double reſource in their neceſſities! Gnats ſeem to partake alſo of this advantage; but as to other inſects, which feed upon blood, ſuch as Bugs and Fleas, I muſt refer, for the ſhifts they can make, to future experiments. Another thing remarkable in theſe inſects is, that the honey-juices they ſuck up with the proboſcis, or trunk, are always accompanied by a quantity of air, which may be very eaſily ſeen, eſpecially in the trunk of the Butterfly.

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* The origin of this Fly is, indeed, very ſtrange. The parent lays its egg in the fundament of a horſe, watching the opportunity of the creature's voiding its excrements for this purpoſe. From this egg are produced the Worms which farriers call Bots, in the inteſtines of horſes. Having lived their time in the creature, they are voided with its dung, and take their chance for paſſing the Nymph-ſtate upon or juſt under the ſurface of the ground; after which they appear Flies, like the parent.

In this order alſo I rank the Horſe fly, particularly ſo called, of which I have, as I think, ſeveral different ſpecies. I cannot indeed poſſitively affirm, thas they all properly belong to it; for to do that, I ſhould have many more obſervations, which I muſt leave to be made by others that can take due pains, and have more lieſure.

Fourthly, I place in this order the Vermiform Nymph of the ſtingleſs Bee, or Muſcaſtercorariae, or Dung fly, of Goedaert; tho' it agrees with the laſt mode or method of this order; for its Worm has a much more delicate skin, than the Worms hitherto taken notice of as belonging to the former mode; ſo that its Vermi-form, or Worm-like Nymph, differs greatly in ſome parts from the form of the Worm in which it before appeared. This Worm is beſt diſtinguiſhed by the extraordinary length of its tail. It is produced from eggs which the Fly, to which it turns, depoſites alſo in neceſſary houſes. Amongſt the Flies to be ſeen in ſuch places, ſpecimens of which I preſerve in my Muſæum, there is one of which I have now been ſpeaking, with feet, horns, and tail, and likewiſe its Vermi-form Nymph with the ſame parts. All theſe little creatures are ſeparately exhibited in Tab. XXXVIII.

Fifthly, I refer to this order the Vermi-form nymph of the Acarus, which exhibits, though ſomewhat obſcurely, the ſhape of its Worm; for as its skin is very tender, it contracts itſelf ſo as to appear externally of an oblong round figure like an egg. I can oblige the curious with a view of this Worm's Nymph, the skin it caſts, and the Fly it produces; and for the preſent, they may amuſe themſelves with Tab. XLIII. where theſe curioſities are all repreſented as big as, and alſo bigger than the life, and with the ſeparate deſcriptions that I have given of them. One thing very remarkable in theſe Flies is, that in its act of copulation, the penis of the male receives into its cavity the vulva of the female.

Sixthly, I count of this order the Vermi-form Nymph, of a certain greeniſh Worm without legs, that lives upon the leaves of cabbage, and of which I intend to give a hiſtory in its proper place. In the mean time, I preſent the readers with figures of the Worm itſelf, its true Nymph, and the Fly iſſuing from it, in Tab. XLV. Fig. XXVI. and following figures. This Worm in the Nymph-ſtate loſes more of its form than the Acarus, as it has a more delicate ſkin; but this particular will hereafter be taken notice of in the hiſtory of the inſect.

Seventhly, I give in this order, which I have eſtabliſhed, all thoſe Vermi-form Nymphs, or, as ſome call them, eggs of Worms, which are nothing but the Worms themſelves contracted into the form of an egg, and are very prepoſterouſly thought to proceed from putrified animal ſubſtances. Such Worms, after loſing all motion, change to true Nymphs within their external skin; and ſo reſemble Vermiform Nymphs; from which in a few days, there proceed a great number of different kinds of flies. Nor do theſe flies differ only from each other, but likewiſe the Worms, from which they originally, and the Vermi-form Nymphs from which they immediately proceed, have the ſame variations; for ſome of theſe Nymphs are in appearance more like eggs than others, in proportion to the delicacy of the Worm's ſkin which produces them, or to the reſemblance which the Worm itſelf has to an egg.

All thoſe Worms void their excrements on the fleſh upon which they feed, which not only makes ſuch fleſh putrify, and ſtink the ſooner, but increaſes its natural ſtench and putrifaction. Redi has deſcribed many ſpecies of thoſe Vermiform Nymphs; but he calls them all eggs, without making the leaſt mention of their being the real Nymphs of Worms, changed to that ſtate, without caſting their external ſkin. However, we muſt allow him the honour of having proved, by the moſt ſolid arguments, that theſe Nymphs, or eggs, as he calls them, are not generated of putrifaction.

Eighthly, I innclude, in this fourth order, all theſe Worm-like, or, as they are called egg-like Nymphs, produced from contracted Worms, which we know, by obſervation, conceal themſelves in the bodies of living Caterpillars, out of which they again eat their way. Theſe Worms then loſe all motion without caſting their external ſkins, ſo as to aſſume the appearance of Vermiform or Worm-like Nymphs; and, in a few days more, they turn to many very different ſpecies of Flies. I muſt own it an error, to give the epithet of Oviform or egg-ſhaped to every kind of Nymph produced in this way; for, there is, on the contrary, ſo great a variety in their forms, that it would be the buſineſs of an entire treatiſe, to give ſeparate deſcriptions and figures of them all.

I do not find that theſe Worms void any excrements, after quitting the bodies of the Caterpillars upon which they feed; they immediately contract themſelves, and become motionleſs within their external ſkin, till at laſt they are thus under its coverture changed into true Nymphs, in every reſpect like thoſe already deſcribed, as belonging to the firſt ſpecies or method of the third order. This kind of mutation in inſects, performed by their contracting themſelves into the Nymph-form, after gnawing a paſſage out of the bodies of Caterpillars, into which they had inſinuated themſelves, has not as yet, as I know of, been obſerved by any writer.

I have alſo remarked, that theſe Worms have ſometimes remained in the hollow of the Caterpillar's body, after they had entirely devoured its fleſh, and thus turned to Flies, after paſſing thro' the Nymph-ſtate; ſo that, in order to appear, they muſt have forced a paſſage through three different ſkins, namely the membranaceous ſkin immediately covering the Nymph, the external ſkin of the Worm from which they originally proceeded; and laſtly, the ſkin of the Caterpillar, whoſe carcaſs they had preyed upon.

For want of ſufficient experiments in an affair that would require a great many, I cannot as yet take upon me to determine, how the Worms, of which I have been ſpeaking, come to be found in the bodies of Caterpillars; whether it be that they are introduced into them in the form of eggs, or whether they proceed from them as from an internal principle? A great deal may be ſaid in favour of either ſyſtem; it is therefore neceſſary, that I ſhould defer, for ſome time, the diſcuſſion of this important queſtion, as I cannot yet produce any ocular demonſtration to ſupport either opinions. Nevertheleſs, I muſt obſerve to ſuch as are fond of natural hiſtory, that it is impoſſible for them to gain a competent knowledge of the diſpoſitions and changes of Caterpillars, without feeding on purpoſe a great number of thoſe inſects of the ſame ſpecies, in order to have an opportunity of tracing them through all their changes: nor will this care alone be ſufficient, for nothing but repeated diſſections can give any ſatisfactory idea of their internal parts. The naturaliſt, who ſhould think of ſucceeding in any other manner, would loſe his pains, and remain in perpetual ignorance.

Ninthly, I reckon, among the creatures of my fourth order, thoſe Vermi-form Nymphs, or, as they are otherwiſe called Eggs of Worms, which are produced by thoſe contracted Worms, which, it is pretended, iſſue from the putrified bodies of Aureliæ. We ſee great numbers of different kinds of Flies, iſſuing from ſuch Worms, in a few days after they become motionleſs, within their ſkins, and thereby aſſume the appearance of theſe Vermi-form nymphs we have been diſſecting. Mouffet was the firſt who took notice of theſe kinds of mutation. After him Goadaert treated of them; and ſince him Redi, and many other authors. I have given by itſelf, Tab. XXXVIII. Fig. x. a drawing of one of theſe Worms, and likewiſe of one of the Vermi-form Nymphs, whoſe reſemblance to an egg is merely ſuperficial.

I place alſo in this my fourth order, the Vermiform Nymphs proceeding from Worms, which, contracting themſelves within the bodies of Aureliæ, without caſting their external ſkin, thus acquire the ſhape of an egg; this is a thing which I very ſeldom have had an opportunity of ſeeing; for theſe Worms generally open themſelves a paſſage out of the Aurelia, as ſoon as they have acquired their full growth, as I have ſhewn already. There is ſufficient reaſon why they ſhould do this. The Chryſallides are generally ſomewhat moiſt, which makes it neceſſary for the Worms contained in them, to leave their bodies, and find out a more convenient ſituation for their external ſkin to harden, in order to their becoming Nymphs. But whenever it happens, that when all the moiſture of the Chryſalis is exhauſted by theſe Worms as their food, ſo as to permit the ſkin of the Chryſalis itſelf to harden and grow dry, then the encloſed Worms remain within it till they become Nymphs, and from Nymphs, Flies, to appear abroad; in which form they muſt alſo make their way through three different ſkins, as well as the Flies generated in the bodies of Caterpillars, whoſe labours on the like occaſion, have already been taken notice of.

All thoſe Nymphs of our fourth order, hitherto taken notice of, change in the end to different kinds of Flies, as has been already obſerved, and I preſerve a great variety of the Flies produced from them, among my other natural curioſities.

Having thus enumerated the inſects that properly belong to my fourth order, I ſhall finally add to it all the Nymphs of thoſe Worms of the firſt, ſecond, third, and fourth orders, which are changed into the ſaid form of Nymphs, within the bodies or ſkins of other Worms, of Caterpillars, Nymphs, or Chryſallides, as likewiſe thoſe changed within the ſeveral excreſcences of trees and their leaves, in form of warts, galls, and the like. However, I muſt obſerve, that I do not rank ſuch Nymphs in the fourth order, as having any further right to it, than that of becoming Nymphs, like the Worms which really belong to it, in an obſcure, hidden, and myſterious manner. A perſon muſt have great experience in theſe little creatures, to be able to ſpeak of them with certainty in their whole hiſtory.

In the eleventh place, I likewiſe reckon of this order, all thoſe genuine Nymphs which are to be found within the body or ſkin of any Worm or Caterpillar, and are the offspring of Worms, which have preyed upon the fleſh of that Worm or Caterpillar in which they are found. Thus it now and then happens, that a Worm or Caterpillar, not having ſtrength enough to caſt its ſkin, becomes hard and firm, without loſing any thing of its external form; in which caſe, the worms that have hid themſelves in it, devour all its fleſh, and being freed in this manner from any neceſſity of altering their ſituation, they change there to genuine Nymphs, and afterwards to Flies. Sometimes a ſingle Worm of an extraordinary ſize poſſeſſes himſelf in this manner, of the whole body of another larger Worm, and without ever leaving it, becomes therein a Nymph, and afterwards a Fly. But if the Caterpillar ſhould retain vigour enough, notwithſtanding ſuch cruel treatment, to throw off its external ſkin, and reach the ſtate of a Chryſalis, then the body of ſuch Chryſalis becomes the ſcene of all the foregoing mutations.

What ought to be conſidered as a greater paradox than all, is, that theſe Worms ſometimes deſert the body or ſkin of the Caterpillar, upon which they had hitherto preyed, and upon deſerting it, encloſe themſelves in an oviform web, within which, they at length change to real Nymphs, and afterwards into Flies. I ſhall have an opportunity of treating this ſubject more at large, when, if it pleaſe God, I come to publiſh my ſelect obſervations; ſo that at preſent, I do not pretend to treat of this change in a particular manner.

Twelfthly, I refer to this fourth order thoſe genuine Nymphs, which become ſuch from Worms, within the ſkins or bodies of Chryſallides, in the ſame manner with the Worms of our third order, and firſt method; but I mean only ſuch Nymphs as are found ſingle in the Chryſallides corroded by them.

I have obſerved, that thoſe Nymphs are of many and various kinds, and indeed ſo different one from another, that it would be a difficult taſk to deſcribe them ſo as to be diſtinguiſhed each from the reſt, without the help of particular figures. There is one thing remarkable in ſuch Nymphs, which is, that we may eaſily obtain a full and ſatisfactory view of their change from the Worm to this ſtate, and of the admirable order obſerved by nature, in affecting this tranſmutation, ſo as to trace with our eyes the mutation hitherto conſidered as a metamorphoſis of the creature, from a Worm to a flying Inſect.

I cannot therefore ſufficiently wonder, that none of the authors, whoſe works I have read, have taken any notice of the Worms now under our conſideration, or given us any drawings of the Nymphs of ſuch Worms. Goedaert, it is true, was acquainted with the Flies, to which they at laſt change, and has given us pretty good figures of them. To deſcribe theſe Flies in a few words, I need only remark, that I have already taken ſufficient notice of them under the name of the Pſeudo-ſphecæ in the detail of my third order, to which they properly belong: in that place too, I obſerved, that Goedaert's devourer or deſtroyer of Spiders, ſhould be looked upon as a Fly of the ſame tribe.

I ſhall now deliver the method of viewing theſe moſt ſingular and intereſting changes. Care muſt be taken to obſerve when the Chryſallides harden, and change colour; juſt at that time they are to be broke open, and the encloſed Worm taken out, and put into a little box, where you may very diſtinctly and conſpicuouſly behold its gradual change to a Nymph, and from a Nymph to a Fly. I ſhall, at another time, with God's permiſſion, and with a view of promoting the glory of the wiſe and powerful Creator, endeavour to ſet in the cleareſt light, among my ſelect obſervations, the manner of ſuch mutation; and likewiſe to ſhew what a great quantity of excrements this Worm voids in the mean while; and how it ſometimes is obliged to ſpin a web, with many other particulars very well worth the attention of the curious. At preſent, I have not oppportunity to dwell any longer upon this ſubject.

In the thirteenth place, I count of this order thoſe Nymphs which become ſuch, and afterwards Flies, from fifty to two hundred together, in the ſame manner with the Nymphs laſt mentioned, within the body, or ſkin of a ſingle Chryſalis, and proceed originally from a great number of little Worms that have preyed upon this Chryſalis. Theſe Flies alſo were known to Goedaert, though he was altogether ignorant of the true manner of their generation, or the real nature of the Nymph, by which alone theſe hitherto ſo perplexing appearances can be ſolved. Nor ſhould I have ſucceeded any better than thoſe who have gone before me in this province of Natural Hiſtory, had I not, purſuant to the advice of the immortal Harvey, called anatomy to my aſſiſtance, upon every occaſion, and laboured with inſuperable patience to diſcover, and diſtinctly comprehend, the true principles of thoſe ſurpriſing changes, as often as there was a poſſibility of diſcovering and comprehending them. Without experiments, we cannot expect any clear and certain knowledge in matters of this kind, whether our concluſions are drawn immediately from our own reaſonings concerning the things before us, or from inductions built upon their reſemblance to others, we are equally liable to go aſtray, and miſtake the productions of our own imagination for the repreſentations of nature, as ſubſequent experiments generally prove. Deſcartes therefore had great reaſon to ſay, that he ſet more value upon the ſolid experiments of mechanicks, than the barren and fine-ſpun contemplations of philoſophers. The creatures juſt taken notice of, as appearing in great numbers within the ſkin or body of a ſingle Chryſalis, may be traced through all their mutations, in the ſame manner with thoſe that require each of them an intire Chryſalis for this purpoſe; and certainly a favourable opportunity of viewing, though but once, ſo great a miracle in the works of nature, muſt afford the higheſt pleaſure to thoſe who are deſirous of being acquainted with ſuch wonders: but now they may eaſily procure themſelves this ſatisfaction, as I have, I flatter myſelf, removed, though not without great pains, the many obſtacles which hitherto oppoſed their deſires.

I place alſo in the fourth order, thoſe genuine Nymphs, which become ſuch from Worms of a particular kind, found within the bodies of larger Vermiform Nymphs, in the ſame manner with the Worms of the firſt mode of the third order. This I had an opportunity of obſerving in the Vermiform Nymph of the common Fly of our neceſſary-houſes; and the ſame is to be obſerved alſo in the inſects of the firſt order.

In the fourteenth place, I muſt add alſo to this order, all thoſe genuine Nymphs which we find in the middle of fruit, in the warts of ſhrubs *, and the leaves of plants, in rotten parts of wood, and in other obſcure and ſecret places. I have collected ſome of theſe Nymphs, and the Flies into which they change; as alſo the ſeveral ſubſtances in which the worms are found; all which the curious are welcome to examine, that the adorable Author of ſuch wonders may receive an additional tribute of praiſe and glory. I preſerve likewiſe ſome of thoſe Flies which proceed from the little Worm, that Redi found within the excreſcencies of willows, without being ever able to diſcover their changes. On opening the bodies of theſe Flies, we meet with eggs, which perfectly reſemble thoſe found in the ſame excreſcences; from whence, as well as from many other obſervations, we may fairly conclude, that all the Worms found in vegetable ſubſtances, are originally depoſited there by the parent inſects in the form of eggs. For a particular illuſtration of theſe things, I muſt refer to the explanations of the XLIV. and XLV. Tables.

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* Theſe all owe their origin to eggs of Flies, and principally to the ſeveral ſpecies of Ichneumon-fly, which this author calls Pſeudo-ſphecæ. All inſects are directed by inſtinct to depoſit their eggs where the young will find food. Butterflies do this on the ſurfaces of leaves. Theſe Flies lodge them in the ſubſtance. They have for this purpoſe a hard and ſharp inſtrument at the hinder part of the body, and with this they bore a hole in the leaf or rind, and lay their eggs. The wound and juices thrown into it by the animal, alter the courſe of the fibres, and hence ariſe galls on the oak; in each of which, there always is a worm originally, the burrs upon the Dogroſe, and innumerable other vegetable excreſcences.

In the fifteenth place, I muſt inſert in this order, all thoſe inſects that change, as it were, into a kind of web. To this claſs or order, more particularly belong thoſe little Worms, whoſe web is ſo fine, tender, and delicate, that a perſon muſt have great practice in things of this kind, to open it without breaking. Within this web, the Worms change to very ſmall Nymphs. I therefore refer to this order Goedaert's Flies, produced from the genuine Nymphs of Worms, which the ſaid author tells us in his xith Experiment, Part I. crept out of the body of a Caterpillar that fed upon cabbages, and then made themſelves each a neſt of a yellow ſilk, in which they afterwards ſhut themſelves up. But Goedaert knew nothing of the Nymphs of thoſe Worms, as appears by all that he ſays in the place already cited. Nor was accurate Mr. Ray, Catalog. Plant. page 137, already mentioned, happier upon this occaſion than Goedaert, whoſe obſervations he was acquainted with. This gentleman imagined, that the Worms here ſpoken of, lay hid within their webs in the form of Worms: he even went further, and committed another miſtake, in thinking that the eggs of theſe inſects, diſtinguiſhed by annular inciſions, were real Nymphs, and not their oblong tranſparent eggs: for thoſe alone are Vermiform-Nymphs, though both in reality certain genuine Nymphs not as yet viſible. I have ſometimes alſo obſerved Worms, which form for themſelves under ground an oviform caſe or ſheath, which a perſon, not acquainted with things of this nature, might eaſily miſtake for a Vermiform-Nymph.

Moreover, I give a place in this order to ſuch Nymphs of Worms or Caterpillars, as are found upon the leaves of willows, encloſed in a very fine and delicate covering, or web of the ſame kind. Theſe Nymphs are changed in time to a very delicate Fly, which the curious may ſee together, with its web or covering, among my other curioſities.

Laſtly, I refer to this order the genuine Nymphs of a kind of Worms, which having made their way through the Caterpillar's ſkin, upon the fleſh of which they had fed, not only ſpin themſelves a covering of white ſilk, but fortify it with a kind of cottony ſubſtance, which the parent Caterpillar had formed for its own uſe; and in a few days after this operation, force a paſſage through both theſe encloſures in the form of Flies. I preſerve in my collection almoſt all the different kinds of Flies hitherto mentioned, with their coverings or webs, ſo that I can give, in a manner, an occular demonſtration to thoſe who deſire it, of every thing that I have advanced concerning them. I have, beſides theſe, many other kinds of webs, which my deſire of making a ſpeedy end of this ſubject, hinders me from enumerating at preſent.

I may include, in this order, in the ſixteenth place, all the genuine Nymphs which have ariſen from Worms, which undergo their changes within very ſlender and delicate habitations of their own forming, and which they conſtantly carry about them, as ſnails do their ſhells, till at laſt they change to Flies, and again betake themſelves to the open air. I preſerve, in my Muſeum, a great variety of ſuch Flies, and their Nymphs and Worms, together with the ſurpriſing caſes of the latter, in which they lie hid, and wherein they walk about with, ſome in the earth, and ſome in the water. Some of theſe Worms are mentioned by Aldrovandus, who deſcribes them by the name of Xylophthori, or Worms that deſtroy timber. I have likewiſe ſome Flies which are produced from theſe Worms, a few of which have been already deſcribed under the name of Ephemeri. Laſtly, it muſt be remarked here, that all the Nymphs of the fourth order, may truly be reckoned of the third, if we conſider them in themſelves alone, and without paying regard to their ſkins, which they do not caſt, or the webs and hidden caſes, in which they conceal themſelves.

Thus I ſhall finiſh this enumeration, and general deſcription of the inſects of the fourth order, which I ſhall hereafter more particularly treat of, and illuſtrate by juſt and careful hiſtories, and convincing examples.

A ſingular example of the fourth order of mutations, exhibited in a Fly; whoſe metamorphoſis, or natural accretion into the firſt form of its limbs, and other parts, I call a Vermiform-Nymph.

TAB. XXXVIII.

N°. I. THE Worm of the common Fly of our privies or boghouſes, repreſented of its natural ſize, and as it appears under its firſt coat or ſkin, in which form it is called an egg. This firſt figure exhibits the egg, as viewed with the aſſiſtance of the microſcope.

N°. II. The double coat or ſkin of the egg, which ſkin or coat the Worm leaves behind it, when it is hatched; or, in other words, creeps out of it. This coat is repreſented as magnified by the microſcope, to twice its natural ſize.

N°. III. The Worm itſelf, ſomewhat bigger than it really is, when it has juſt crawled out of the membrane, in which it was concealed under the form and name of an egg.

N°. IV. The ſame Worm, arrived at its full growth, and crawling about. As the feet of this Worm are very ſhort, and narrow withal, it always moves, and, as it were, draws itſelf forward by the help of its head or beak: therefore, if you put it on a ſmooth piece of glaſs, it walks with great difficulty; whereas, upon a coarſe cloth, it will advance pretty briſkly; for it thruſts its head into the little hollows and cavities of the cloth, and very nimbly draws up to the head, where thus anchored as it were, the reſt of its body, which has only very ſhort feet about the hinder part of the belly. In this reſpect, therefore, the Worm, of which I am ſpeaking, agrees very remarkably with the water Worm, from which the Aſilus or Gadfly proceeds. The Worm of that Fly carries its feet, as it were, in its mouth; but I cannot pretend to ſay the ſame thing of the boghouſe Worm, as I have not as yet examined it ſufficiently; though I think it very probable, that its principal feet are ſituated in that part. The third figure exhibits this Worm increaſed by the microſcope, to a conſiderable magnitude.

N°. V. I exhibit in this place the Worm already repreſented under the form it has, after loſing all motion, without caſting its ſkin; within which, notwithſtanding, it becomes a genuine Nymph: and its becoming a Nymph, in this manner, muſt, I think, be looked upon as a ſufficient reaſon for my giving it this new name of the Vermiform-Nymph, ſince, at the ſame time that it retains the appearance of a Worm, it really changes, under ſuch appearance, to a genuine Nymph. This ſpecies of Nymph, with the Worm's ſkin upon it, in the fourth figure, as it appears when magnified by a microſcope, and the Nymph itſelf ſtripped of its ſkin, is exhibited in the fifth figure, ſomewhat larger alſo than nature: but the ſixth and ſeventh figures, next following, repreſent it magnified to much larger dimenſions.

N°. VI. Exhibits the boghouſe Fly in its perfect ſtate, as it appears when it has caſt its two ſkins together; namely, the external hard ſkin, in which it had the ſhape of a Worm, and under which it continued when changed to a Nymph; and the internal and more delicate ſkin, proper to it as a Nymph; for this inſect throws off both theſe skins at the ſame time. We may obſerve here, with what extraordinary elegance it is cloathed, when the time is come for it to appear abroad, and attend to the great work of propagating its ſpecies! The eighth figure exhibits the Fly, as it appears when greatly magnified by the microſcope. I ſhall hereafter explain this figure at large, when I come to deſcribe the inſect's external ornaments. There is, it appears, a remarkable difference between this order of changes and the firſt; as, in the firſt, the creature iſſues perfect from its egg, without paſſing through any intermediate ſtate. This order differs alſo from the ſecond, as the inſects of that order acquire certain membranaceous caſes or coverings of the parts within, which riſe above the reſt of the ſurface of their bodies. And, finally, it differs from the third order, in which the creatures caſt, at different times, the skins wherein they appear as Caterpillars, and the covering they afterwards wear in the form of Nymphs; for, in the fourth order, both theſe coats come off together. On the other hand, the inſects of all theſe orders have thus much in common: they are Nymphs under all theſe ſtates, and in every order; and they ſo long and ſo often change their skins, till they are become perfect and ready for the work of generation. The Nymph, therefore, having its place in all the four orders, is the true, the only, and immutable foundation, upon which the changes of all theſe inſects depend, as I have attentively and at large demonſtrated in the beginning of this work. I make only a curſory mention of it in this place, the better to fix ſo important a truth in the memory of my readers.

TAB. XXXVIII. FIG. I.

By this figure, which repreſents the boghouſe Fly's egg bigger than nature, we obſerve that it is of an oblong and angular conſtruction, ſo as to form, in a manner, an elegant, chequered, and reticulated repreſentation of that kind of cake known in Holland by the name of Woffel. Theſe eggs are of a delicate whiteneſs, and they have two integuments, which are eaſily diſtinguiſhed one from the other. The outer integument is the real ſhell; and this is, in every reſpect, like the ſhell of a hen's egg, as appears by its breaking to ſmall pieces in the fingers. By this means it is an eaſy matter to ſeparate this outer cruſt from the internal covering, which properly contains the embryo of the boghouſe Worm. As theſe eggs are moiſt when juſt laid, and are depoſited by the parent Fly upon the walls of boghouſes, and ſometimes even in the skins ſhed by former Nymphs, they ſtick together, when the air has dried the intervening humidity; ſo that, on endeavouring afterwards to ſeparate them, part of the external ſhell of one egg comes off, with the inner ſubſtance ſticking to it. By this means the angular form of the latter acquires a kind of projecting border. This was the caſe with the egg here repreſented, which I thought proper to exhibit in that form, in which alone I could procure it ſingle, on account of its firm coheſion with the adjacent eggs.

FIG. II.

I here repreſent the delicate internal membrane which covers the egg, as it appears about the fore-end of it. This membrane has been broken by the boghouſe Worm, when it crept out of the egg; ſo that we may ſee in what manner the external cruſt or ſhell has been cracked upon this occaſion, and how it has crumbled off from the internal membranes. It is very ſurpriſing how theſe eggs are covered with ſo hard a ſubſtance, reſembling plaiſter of Paris; though it ſeems probable that Nature ordained it ſo, the better to ſhelter the encloſed embryo Worm from the putrid and ſharp effluvia ariſing from boghouſes, in which places it is often depoſited. This led me to an experiment, by which I have found, that the ſaline acrimony of urine makes no impreſſion upon theſe eggs. But it is not in boghouſes alone theſe eggs are to be found: we meet with them in ſeveral other places, particularly where fruits, herbs, and other ſucculent vegetables, lie and rot. But they appear no where ſo beautifully, or to ſuch advantage, as in the Oviducts of the female Fly, opened for this purpoſe; and, no doubt, the moſt certain method of inveſtigating the eggs of inſects, ſo as to obtain ſome certain knowledge concerning them, is that by diſſection of the inſects; but then the opening of theſe ſmall animals at the exact time, when their eggs are perfect in the Ovary, and ready for laying, depends entirely upon chance.

I have a ſmall box full of inſect's eggs in my collection, ſo very curious, that I ſhould not think a particular treatiſe ill beſtowed upon them; for they all greatly differ from one another in ſhape and colour. Some are oblong, others oval; ſome again perfectly round, others angular; ſome pear-ſhaped, ſome like the ſeed of the carduus benedictus, and others of other forms. There is alſo the greateſt variety of colours amongſt them; white, yellow, red, ſky-coloured, green; and in ſome is to be ſeen a beautiful mixture of ſeveral colours, ſo as to make it almoſt impoſſible to give a particular account of them. Some alſo are ſoft, others hard; ſome are only covered with a ſlight membrane, whilſt others have a ſhell, or firm cruſt, like parchment. Again, ſome are ſheltered by a froth that ſurrounds them, others are covered with hair: ſome are found faſtened by a viſcous matter to the branches of trees, ſo as to form a ring about them; others lie ſingly, and at random. Some ſtand cloſe to each other upon their ends; others lie parallel to the horizon; and ſome are found buried in animal and vegetable ſubſtances, whilſt others are only laid in a looſe manner upon the ſurfaces of ſuch things.

Fig. III.

I here lay before the reader a figure of a Worm, which changes to the boghouſe Fly, as it appears when magnified by the microſcope. We may clearly diſcern in it thoſe annular diviſions, of which ſome conſtitute its head, the next to them the thorax, and the hindmoſt the creature's abdomen and tail. The circumference of every part of the body appears adorned with ſeveral, as it were, prominent feathered bandages. But the inſect loſes the advantages of theſe as ornaments, becauſe it cannot but foul them, by crawling through the offenſive matter upon which it feeds. For this reaſon it ought to be well waſhed, in order to become fit for a microſcopical obſervation: nor need we fear to do it any injury, by treating it in this manner; for it has a ſtrong conſtitution. Beſides, this Worm is one of the ſpecies of inſects which have a hard ſkin, the better to reſiſt the acrimony of the putreſcent juices, amongſt which it lives. This hardneſs of the boghouſe Worm's ſkin, is the cauſe of its not loſing its external form, when it changes to a Nymph.

Fig. IV.

It muſt be here very thoroughly conſidered, that theſe Worms, on their aſſuming the ſhape of Vermiform-Nymphs, become motionleſs, and ſoon after draw up their ſnout within the head; by which, and by a contraction of all the rings of their body towards each other, they become ſhorter, in ſo conſiderable a degree, as may be ſeen in the fourth figure now before us: which likewiſe ſhews, that there is but little difference between the Worm repreſented in the third figure, and the Vermiform-Nymph exhibited in this place. The only difference is this, that the Nymph is without any motion, whereas the Worm moves itſelf very briſkly. The drawing in of the ſnout in the Nymph, ſcarce makes any difference; for the Worm itſelf is very often obſerved to do the ſame thing. But we muſt here take ſpecial notice, that all the Worms of this fourth order are not all changed to Nymphs, in the ſame manner with the ſpecimen of that order, which I here explain: neither do all the Nymphs equally exhibit the former limbs of their reſpective Worms; the only reaſon of which diverſity I take to be this, that ſome of theſe Worms have a more delicate ſkin than others, and conſequently it is better adapted to conform itſelf to the ſhape of the latent Nymph, when the inſects change into that condition. This I ſhall demonſtrate in the ninth and tenth figures, by two particular and very evident examples, which will ſupply us with a rule to judge by, in every caſe of the like nature.

There is one circumſtance more worth our notice in the Nymph, whoſe figure we are now conſidering: this is, that I have repreſented its fore-parts, about the head, ſomewhat whiter and brighter than the reſt of the body; becauſe the hidden Nymph, by the inſenſible evaporation of its moiſture, gradually contracts itſelf more in this part than elſewhere, ſo as to leave a vacant ſpace, which, by affording a free paſſage to the rays of light, thereby, in reality, acquires an extraordinary degree of brightneſs. This particular I took notice of in a Nymph, like this I am now deſcribing, of the Muſca Aſilus, or Gadfly, whoſe hiſtory follows this. It is likewiſe plain, that the empty part of the ſkin, in the foregoing Nymph, may be dexterouſly cut off with ſciſſors, without wounding the encloſed inſect; and, upon doing ſo, we may ſee that the Nymph's head lies in the fore-region of the Worm's ſkin; and that its eyes, which, in the beginning of the change, were of a milky white, are at this time turned to a purpliſh red. However, this experiment ought only to be tried upon Nymphs which are ſeveral days old; for we ſhould certainly injure thoſe that were younger, in the operation. It happens in this Worm, as it does in all others of the fourth order, that the thorax conſtantly continues the ſame in the Nymph-ſtate, without any viſible alteration: in the ſame manner, as in Worms and Caterpillars of all the other orders, the legs, ſpringing from the thorax, never change their ſituation. But this laſt circumſtance chiefly obtains in the ſecond order, of which there are a great number of inſects, whoſe thorax, and eſpecially the legs belonging to this part, do not ſuffer the leaſt alteration; that is, they neither grow longer or ſhorter at the periods of the inſects caſting their ſkins.

Fig. v.

I here give a figure of the encloſed hidden Nymph, as it appeared ſomewhat magnified, when cut out of the external ſkin, or that of the former Worm, which before covered it.

Fig. vi. and vii.

Theſe two figures repreſent the ſame Nymph magnified by the microſcope to a proper degree. We may ſee in theſe in what manner it is divided into a head, thorax, and belly, which I ſhall more particularly explain in the next figure, which likewiſe exhibits the ſame Nymph.

Fig. vii. *aa.* Are the inſect's eyes ſeated in its head, and formed like a net; between theſe, but lower near the thorax, appears its proboſcis, or trunk.

b. Are two little horns or antennæ, which ariſe from the upper part of the head.

cc. The folded legs riſing from the thorax, three on each ſide.

dd. The folded wings, between which the extremities of the legs are cloſely arrayed.

e. The annular diviſions of the abdomen, and certain prominent tubercles upon the edge of it, being what remains after the inſect caſts the ſkins of the feathered protuberancies of the Worm and Nymph, which I have abovementioned. Theſe tubercles diſappear when the creature aſſumes the form of a Fly. They are either entirely deſtroyed by the evaporation of the humours, or thrown off by the hairs that grow in this part. It is a very tedious and difficult task to diſſect the real Nymph of the tender membranaceous ſkin, which immediately covers it under the outer integument, without either hurting or diſplacing its limbs.

Fig. viii.

This figure exhibits, larger than life, the Nymph free from its two coverings, and changed to a Fly; but it muſt be obſerved, that it does not, on parting with its ſkin, fold or curl them up, as Hornets and Bees do; this creature only breaks them near the place where its head lies, and leaves the caſe unimpaired in every other reſpect: ſo that on ſeeing one of theſe deſerted coverings, one would be apt, at firſt ſight, to take it for an entire Nymph. This Fly, which from the form and condition of a contemptible and filthy bog-houſe Worm, is changed to an inhabitant of the air, thus making miſery its way to happineſs, is divided in a very diſtinct manner into the head, the thorax, and the abdomen.

Fig. viii. *aa.* In the head are two eyes formed like an elegant piece of net-work, and of a purpliſh colour. Theſe eyes are ſeparated by two very elegant zones of a ſilvery whiteneſs, in the part where they come neareſt to one another.

b Between theſe ſilvery zones, on the forepart of the head near the eyes, are the inſect's two horns, or antennæ.

cc It has likewiſe two membranaceous wings fixed to the ſhoulder-blades of the thorax.

dddd Are ſix legs covered with ſtiff hairs; theſe are articulated with the lower part of the thorax, and they conſiſt each of four joints: that which forms the foot, properly ſo called, is again divided into ſeveral leſſer joints. We may, beſides, ſee very diſtinctly, that every leg has diſtinctly two claws at its extremity, and that theſe claws are parted by ſome hairs that grow between them.

e Here we may ſee the rings and variegations by which the abdomen is divided. They are covered with hair reſembling briſtles. Indeed, the whole body is thick ſet with this kind of hair, and it is of a blackiſh gray, without any other particular ornaments of colour, tho' in many other Flies we perceive a moſt delicate mixture and combination of colours; ſo that the Fly now under conſideration, deſerves only to be ranked amongſt the moſt ordinary ſort.

Fig. ix.

Finally, to give a perfect idea of this fourth order of mutations, I ſhall add a ſuccinct account of two particular Nymphs, which belong to it, tho' under the ſecond mode; for theſe Nymphs differ greatly from thoſe of the ſame order already deſcribed: they are altered in a great meaſure from the ſhape they had in the Worm ſtate, tho' one of them much more than the other; the reaſon of which variation I ſhall likewiſe endeavour to point out.

Tab. XXXVIII. Fig. ix. A.

The Worm here repreſented, is the ſame with that of which Goedaert has given us a deſcription, and a figure in the firſt part of his work, obſervation 11, but without taking any notice of its feet or horns, both which he overlooked. I cannot ſay, that I have myſelf counted theſe feet in a living Worm; but on examining a preſerved one, and its Nymph, there appear ſeven on each ſide, and thoſe are all armed with ſome little claws. Theſe feet are very ſhort, and ſcarce viſible, except when the inſect extends and thruſts them out. Goedaert does not deny the exiſtence of theſe feet, in his Dutch work, publiſhed under his own inſpection, but his Latin tranſlators do it for him: from whence it plainly appears, that thoſe gentlemen, who have likewiſe added their own obſervations to Goedaert's work, have diſgraced his performance by a great many errors and miſtakes. We have reaſon alſo to lament, that this induſtrious naturaliſt employed others to write, even in Dutch, the obſervations which he had made in this province of natural hiſtory. We muſt expect to find their particular opinions frequently intermixed with thoſe of the illuſtrious original writer. But be that as it will, one thing is certain, that the original Dutch is preferable in correctneſs, and other reſpects, to the Latin tranſlation.

The two antennæ, or horns of this Worm, which it carries on the forepart of its head, and its long tail, which it ſometimes twiſts and turns about in a very ſurpriſing manner, contribute greatly to give it a ſingular and pretty appearance.* Its body is divided into ſeveral rings, which ſometimes appear much rounder than at others. The colour is of a ſky gray, approaching a little to brown. It is a miſtake to think, this Worm proceeds from putrefaction, as Goedaert, or rather his commentators have advanced. It is produced from an egg depoſited in bog-houſes by a Fly like that, to which it is itſelf one day to be changed. I have ſometimes alſo found theſe Worms crawling in vaſt numbers, and in a ſtrange manner amongſt one another, in meadows, in barns, and among very moiſt cow-dung. Theſe inſects are of a very ſlow growth; ſo that they do not change till the month of Auguſt. I have hitherto taken but a very curſory ſurvey of their internal parts; their pulmonary veſſels appeared to me to be thoſe that beſt deſerved further obſervation.

B.

When theſe Worms are about to aſſume the appearance of Vermiform Nymphs, as is repreſented in the ninth figure, under the letter B, they remove themſelves out of the excrements wherein they have hitherto lived, to ſome dry place, where they draw all their parts together. I have even ſometimes obſerved theſe Worms fixed to the walls of country cottages, where they had climbed up to twice a man's height, in order quietly to go through their mutations. This important buſineſs is executed in the following manner. Firſt, the Worm's tail is wrinkled up, and contracted by drying, and ſometimes it curls itſelf up, ſometimes not; ſometimes even it grows quite flat by drying, as it hardens to a greater or leſs degree, or as it has taken up more or leſs time in hardening; then the reſt of the body becomes wrinkled up, and ſo contracted, that its rings are in a manner forced together into one. But as the skin of this Worm is ſomewhat ſoft, it conforms to all the ſhapes that the hidden Nymph aſſumes in its progreſs towards the Fly-ſtate; and this is the true reaſon why this Vermiform-nymph deviates a little from the appearance of the former Worm. I ſay a little, becauſe we may ſtill perceive in it, the skin of the Worm, its tail and legs: but above all, the antennæ, or horns differ; which in this Vermiform-nymph project more from the head, than they did in the Worm itſelf; beſides this, from being ſoft and pliable, they become hard and ſtiff at this time. By dexterouſly opening the external ſkin at this period, we may obtain the true Nymph it conceals in ſuch great forwardneſs towards the Fly-ſtate, that it exhibits diſtinctly the parts peculiar to that creature, the horns or antennæ eſpecially, which are diſpoſed, as in a caſe, within thoſe of the former Worm.

C.

When the Nymph we are treating of, has thus lain hid for about ſixteen or ſeventeen days in the unaltered ſkin of its Worm; it is ſufficiently grown and changed to appear abroad, and ſo at once forces its way in the form of a perfect and very handſome Fly thro' the ſaid ſkin, and the internal membrane immediately inveſting it; as is common to the inſects of this fourth order. This Fly is beautifully divided into the head, thorax, and abdomen; it has two eyes, two little antennæ or horns, ſix legs, a pair of wings, and its body is covered with hair. Its back and tail are yellow and red, delicately interſperſed with black ſpots: it is repreſented in the ninth figure, under the letter C.

Some authors have fancied, that this inſect ought to be ranked amongſt Bees, as appears in Clutius's treatiſe on Bees, where he cautions the unexperienced againſt ſo groſs a miſtake. However, Dr. J. de Mey, regardleſs of ſuch notice, falls into this error in his notes upon Goedaert, where he prodigiouſly magnifies the hiſtory of this inſect as a real Bee. In this he gives evident proof of his little acquaintance with either the Bee or the Fly-kind. Thus the vain temerity of our corrupt nature makes us attempt to paſs our judgment upon things of which we know nothing; with a view of paſſing for perſons of knowledge and wiſdom upon others as ignorant.

Fig. x.

I here repreſent a Worm, that has pierced the ſkin of a Chryſalis, like that exhibited in Tab. XXXVII. N°. V. and has deſerted it afterwards in ſearch of a more proper place in which to perform its changes.

D.

This Worm is divided by a great many annular ſections. Its colour is white; its ſkin is ſoft and tender. It moves itſelf by the annular contraction and extenſion of its rings, and it continues this motion in its preſent ſtate, till being quite ſpent, it quietly lies down to give way to the ſecret operations of nature, in the change of its condition.

E.

While this is preparing, we may obſerve, that the head and tail of the Worm are drawn up, as it were, into its body, though as yet no change happens in the old ſkin, except its aſſuming the ſhape of an egg, in which, ſoon after, there appears a variety of colours; firſt, the body then ſhrivelled up grows white, then yellow, next red, after this of a purple colour, which then acquires a fiery brightneſs, like that, as it were, of a ſparkling red, ſhining like amber; and, laſtly, it turns to a deep brown, which it retains for ſome days without any further alteration.

On laying open and removing the ſkin of the Worm at this period, we find in it a true perfect Nymph, which exhibits moſt diſtinctly all the limbs of the future Fly: ſo that this is a real Vermi-form Nymph, only that it yet repreſents the parts of the former Worm, though in a ſomewhat

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* We have in England three diſtinct ſpecies of theſe Worms; the French alſo have them as common, they call them Vers a que de Rat. They are the offspring of three diſtinct ſpecies of Flies, all reſembling Bees, but with only two wings. The ſpecies here deſcribed, is the largeſt; and it changes into a large Fly, which our obſervers of Inſects call the Drone Fly, from its great reſemblance of the male Bee, which is alſo called the Drone.

what obſcure and confuſed manner: this is owing entirely to the ſoftneſs and delicacy of its ſkin, which ſticks cloſe to the ſurface, and accommodates itſelf to the ſhape and figure of the encloſed Nymph.

By duly attending to the preceding obſervations, we may for the future eaſily underſtand, for what reaſon ſome of theſe Nymphs retain the figure of their former Worms more than others; for, it will plainly appear, that this difference ariſes ſolely from the ſkins of the former Worms, being more or leſs hard or pliable. For thoſe Worms, that have a very dry and hard ſkin, as the Worms of the common bog-houſe Fly, and the Muſca Aſilus, or Gad-fly, cannot but retain their former appearance; whilſt other Worms of a ſoft and delicate skin, cannot but loſe a great deal of it; all which is made evident, by a remarkable example in the tenth figure, under the letter E.

Such being the nature of theſe things, we may plainly perceive how much thoſe naturaliſts were miſtaken, who called the foregoing condition of the limbs, and other parts, a true egg, as may be ſeen in Mouffet, and Goedaert, in the commentators of this laſt, and many other authors. But let no one imagine, that I mention this miſtake, in order either to expoſe the writers, who have committed it, or to deſerve glory from their ignorance: my ſole intention is to publiſh truth, and excite thoſe who love it, to ſearch after it in the works of nature themſelves; for they are capable of teaching us more in a ſingle moment, than all the written accounts of them could do in a thouſand years: but then we ſhould prepare ourſelves for ſuch an inquiry, particularly by laying aſide all manner of prejudice, as it plainly appears, that obſervations attempted upon a wrong foundation, have only ſerved to produce a great number of pernicious errors.

F.

To conclude, I preſent the reader, under the letter F. of the ſame figure x. a repreſentation of the Fly produced from the Nymph I have been laſt deſcribing. It is like the common Fly, divided into the head, the thorax, and the belly. Between the eyes, which are ſeated in the head, and are of a deep purple colour, are two ſilver borders or zones; and between theſe borders are placed a pair of antennæ, or horns. From the ſhoulder-blades ariſe two grayiſh membranaceous wings, and from the fore-part of the thorax, ſix hairy legs. The abdomen is covered with hair, like briſtles, and is divided by ſeveral rings, parted from each other by black rolls or bandages. This Fly, like the preceding, on its quitting the Nymph-ſtate, leaves two skins behind it.

As to the manner in which this ſpecies depoſits the eggs within the Caterpillar, repreſented in No. III. of the XXXVIIth Table, and the courſe in which the Worms ariſing from thoſe eggs, are changed into Chryſallides with the Caterpillar, upon which they feed; or, to ſpeak more properly the manner in which theſe ſmaller Worms come to be encloſed in the Caterpillars Chryſalis, and their management in forcing their way thro' this Chryſalis, I ſhall give a general account of in the progreſs of my ſurvey of this fourth order, and hope I may ſome time, or another, have an opportunity of handling this ſubject more particularly, and ſolving the gordian knot which it contains.

The ſurpriſing hiſtory of the inſect called the Muſca Tabanus, or, more properly, the Aſilus or Gad-fly *.

THE INTRODUCTION.

THE Inſect, whoſe hiſtory I am about to give under the name of the Gad-fly, is ſo wonderful in all its parts, that it may be well ranked amongſt the moſt maſterly works of nature; for, the particulars which induſtrious obſervers have diſcovered in it, are moſt ſingular, and unheard-of in other kinds. The learned Mouffet inveighs ſeverely againſt thoſe authors, who confound this Fly with the Tabanus or Breeze-fly, as he affirms there is an eſſential difference between them, which I have myſelf alſo found to be very true; for, as the ſaid Mouffet very pertinently alledges after Ariſtotle, the Aſilus or Gad-fly, proceeds from a certain little, broad and water inſect. This author remarks alſo, with equal propriety, that the Aſili or Gad-flies are much more ſcarce than the Tabani or Breeze-flies, and they are not to be found except in the neighbourhooud of rivers, and they have a much larger proboſcis or trunk than the Tabani or Breezes. This being ſettled, the Fly that I am here now about to deſcribe, is a true Aſilus or Gad-fly, and ought, by no means, to be calleda Tabanus, or Breeze-fly; for, agreeable to the deſcription given of the Aſilus, or Gad-fly, it proceeds from a little flat water Worm; it flies about fields near waters; and, in fine, it has a larger trunk than the Tabanus or Breeze-fly. Mouffet has given us a true figure of the Tabanus or Breeze; and at the ſame time, has aſſigned the real difference between that and the common Horſe-fly; for there are many ſpecies of Horſe-flies, and the Tabanus or Breeze ought to be accounted one of them. But Mouffet is greatly miſtaken in giving the Aſilus a hard ſnout, with a ſtrong ſting or aculeus fixed to the fore-part of it, theſe particulars being obſervable in the Tabanus or Breeze-fly only. He errs as much in ſaying, that the Tabanus grows at the end of honey-combs. But it was impoſſible, that this author ſhould not commit miſtakes; for, as he had no experience of his own to go by, he was obliged to take things upon truſt from other writers, and conſequently was liable to adopt their errors.

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* The common writers have been very confuſed in their accounts of the two ſpecies of inſects known by the names of the Gad-fly and the Breeze-fly, and have applied the names at random, to one or the other. The Latin denominations of the ſame inſects, Tabanus and Aſilus, have been as ill defined. The creatures are perfectly diſtinct, both in the Worm and Fly-ſtate, and, 'tis to be hoped, that, for the future, they will be ſo underſtood and conſidered, this author having perfectly diſtinguiſhed the words, and aſcertained their meaning by his figures.

I muſt, on this occaſion, deſire my readers to take notice, that in my general hiſtory of inſects, I forgot myſelf ſo far as to deſcribe the Aſilus, under the name of Tabanus; nor can I account for this overſight, as I then made uſe of the words of Ariſtotle juſt now cited. After this preface and remark, I ſhall briefly deſcribe the little creature, from which our Aſilus or Gad-fly proceeds. It is repreſented in Figure I. of Tab. XXXIX. its Nymph in the II and III Figure of Tab. XLI. and laſtly, the Aſilus Fly itſelf, in the II Figure, Tab. XLII.

There are ſeveral very uncommon particulars in theſe ſtates of the ſame inſects in the Worm condition; it lives in the water, breathes by its tail, and carries its legs within a little ſnout near its mouth. When it becomes a Nymph, it performs the change without caſting its ſkin; and when it becomes a Fly, it can no longer live in the water; ſo that the element, which hitherto ſupplied it with life and motion, would now be its immediate deſtruction.

Theſe are all no more than the external wonders; and they appear inſignificant, when compared with the hidden changes and tranſpoſitions of parts, performed within the skin, ſtomach and inteſtines, but above all, in the ſpinal marrow, which it is impoſſible to ſee, without being loſt in aſtoniſhment.

There occur beſides in this treble, though at the ſame time ſingle, little creature, other particulars, ſurpaſſing, in a manner, all human imagination; ſuch as its moſt uncommon alterations of colour, indurations of parts, loſſes of limbs, and acquiſitions of internal organs.

Thus I ſhall cloſe this ſhort introduction, but I cannot too often remind my readers, that they will here meet with a collection of wonders, any ſingle one of which, is worth their moſt perfect attention. Nor are they the lines only of an Apelles, that I deſcribe in this place, but inimitable pictures, and the very handy-work of the great Creator, God himſelf, to whom we are indebted alſo for all that we have, or are, and whom we ought to acknowledge in the humbleſt manner, as our Creator, Preſerver, and conſtant Benefactor. Hence, judge, O man, how incomparable muſt be the elegance of thoſe miracles of his, which ſhall never periſh, when ſo much art and contrivance is to be ſeen, even in the corrupt nature of creatures, that are buried, as it were, under darkneſs, by his great ordinations. Therefore to this all-good, all-wiſe, and all-powerful Being, and to him only, be all the honour and glory of the preſent diſcovery.

CHAP. I.

The external figure of the Worm, from which the Muſca Aſilus, or Gadfly, is produced, repreſented in its natural bigneſs; and alſo as it appears when magnified by the microſcope; with the manner of its carrying its legs, by a moſt wonderful contrivance, in its mouth; and of its breathing by the tail.

Tab. XXXIX. Fig. I. *a.*

THIS Worm, viewed with the naked eye, appears to conſiſt of twelve annular diviſions, *a*, by which it is ſeparated into a head, thorax, and belly; but as the ſtomach and inteſtines lie equally in the two, the thorax and belly, their bounds are ſcarce perceivable, until the inſect, ſtill cloathed in the Worm's ſkin, approaches the Nymph-ſtate.

The parts moſt worthy of notice, that the naked eye can diſcern in this Worm, are its tail and its ſnout. The tail is furniſhed with an elegant crown *b* or circle of hair, diſpoſed quite round it in an almoſt annular form; by means of which, while the Worm moves itſelf in the water, this tail can ſupport itſelf on the ſurface, the body all the time hanging down towards the bottom; and ſometimes it remains thus a long while, without the leaſt ſenſible motion. The ſnout is divided, as it were, into the three parts, *c*, of which that in the middle is altogether immoveable; whereas the two others, which grow at the ſides of the former, vibrate in a very ſingular manner, and, in appearance, are very like the tongues of Lizards and Serpents. The greateſt ſtrength of the Worm is likewiſe ſeated in theſe lateral parts of its ſnout: it is by means of theſe it crawls, when out of the water, ſo that one would imagine it walked with its mouth. Parrots, whoſe upper and under jaws are both moveable, enjoy, in the ſame manner, the privilege of uſing their beaks with ſuch force, in climbing, that they have the greateſt advantage from it. In the ſame manner this Worm, as often as it can lay hold of any thing with thoſe parts that I have been ſpeaking of, appears to move, as it were, entirely by the help of its ſnout. Theſe parts, however, do not conſtitute its mouth, as I ſhall preſently ſhew.

When the Worm, being thus ſupported on the ſurface of the Water by means of its tail, has a mind to ſink to the bottom, it generally bends the hairs of that part a little towards each other in the middle, and much more forcibly at the extremities, without diſturbing them in the leaſt about the roots. By this means a hollow is formed; and the air, pent up in it, looks like a pearl, Tab. XXXIX. Fig. II. *a.* It is by the help of this bubble that the inſect can again gently raiſe itſelf to the ſurface of the water, and there remain ſuſpended,

pended. The ſame thing has been obſerved in thoſe Worms that produce Gnats. If at any time the air ſhould happen to eſcape from between the hairs forming this bubble, the inſect has the power of immediately replacing it, by a new ſupply from its pulmonary tubes; and ſometimes even large quantities of air are ſeen to ariſe in bubbles from the tail of this Worm, *b*, to the ſurface of the water, and mix with the incumbent atmoſphere. This is owing to the water's being ſo much heavier than air; it being natural for things, though heavy in themſelves, to aſcend, in order to make way for thoſe that are more ſo.

This extraordinary operation may be eaſily ſeen at any time, by putting the Worm into a glaſs full of water, and it affords a very entertaining ſpectacle; for the air-bubble, encloſed in the tail, looks like a little tranſparent ſilver bladder. I have four ſpecies of this Worm, and of the Fly that is produced from it, all differing in ſize and colour; but without any other conſiderable diſtinction.

As all I have as yet ſaid concerning this Worm, which produces the Aſilus-fly, can give but an imperfect idea of it, I ſhall exhibit it alſo as it appears through the microſcope; and, at the ſame time, deſcribe its external and internal parts. Thus the reader will be enabled clearly to comprehend the deſign and uſe of thoſe little parts, which are ſituated near the tail and the mouth; as alſo, after what manner its lungs receive the air, which is both admitted and diſcharged by the tail. Finally, I ſhall make it evident, that thoſe are really the inſect's legs which are ſeen moving near its mouth, like the tongues of Serpents.

FIG. III.

On examining the external figure of this Worm with a microſcope, it appears to be a little pointed forwards about the head; and its thorax, or that part of it which we may conſider as ſuch, is ſomewhat broader. The body again grows ſmaller, and converges at the abdomen; till at laſt it ends in a ſharp tail, elegantly ſurrounded with hairs, in the form of the rays of a ſtar.

This Worm, the head and tail included, has twelve annular diviſions, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. Its ſkin reſembles the covering of thoſe animals which Nature has provided with a cruſtaceous habit, much more than it does that of Worms, or of the naked Caterpillars. It is moderately hard, and, like that rough ſkin called chagreen, it is thick ſet with an infinite number of ſmall grains, pretty evenly diſtributed. Theſe grains lie ſo cloſe together, that there is not to be found the leaſt vacant ſpace between them; and they are ſmaller in thoſe parts, where the rings of the abdomen are pointed to each other, than upon the middle of the rings. This diſpoſition renders the ſkin more flexible, and conſequently facilitates the turnings, and other motions, of the Worm's body. The true conſtruction of theſe grains is ſeen, on viewing them with the greateſt magnifier, Fig. IV. and I give a ſeparate drawing of them upon a ſmall portion of the ſkin. This figure alſo ſhews us how the ſkin, *a*, looks in the interſtices of thoſe grains. Thoſe grains are very thick, and convex in the middle, *b*: near their edges they appear as conſiſting of many rings, *c*, which join each other; and form a great many irregular points, *d*, ſo as to add great ſtrength and firmneſs to the grains themſelves. The ſubſtance of thoſe grains is a very firm horny bone; and I make no doubt but the ſkin of this Worm might be made uſe of, in turning, to poliſh the harder woods, as ebony and box, in the ſame manner that the ſkin called chagreen, juſt now taken notice of, is ſucceſsfully applied to the ſame purpoſe.

There are alſo nine puncta reſpiratoria, breathing-holes, or points of reſpiration, on each ſide of this Worm's body; but I here repreſent only twelve of them, nine at one ſide, and three at the other. There are no ſuch holes viſible on the outſide of the tail, Fig. III. *a*; nor in the third ring, counting from the head: for the tail has, at its extremity, openings for the admiſſion and expulſion of air, as already taken notice; and in the third ring the breathing-holes only appear under the ſkin, and are very ſmall, as it is hereabouts the embryo wings of the future Fly lie concealed. It is very remarkable, that this Worm ſhould have but one ring without thoſe breathing-holes; whereas Caterpillars always have two without them. The reaſon of this difference ſeems to be, that moſt Caterpillars change to Flies with two pairs of wings; whereas the Worm, under our conſideration, changes to a Fly that has but a ſingle pair.

Above theſe pulmonary openings, there beſides appear a great many black ſpots; but they are much ſmaller than thoſe formed by the breathing-holes. Theſe leſſer ſpots ſeem intended merely for ornament. They ſhed a ſkin, ſo that they are ſtill ſeen in the inſect, when arrived at the Nymph-ſtate.

The ſkin has only three colours: it is adorned with oblong black furrows, ſpots of a little lighter colour, and orbicular rings; from the middle of which there generally ſprings a hair. In the figure before us, only the hairs that grow on the inſect's ſides are repreſented, Tab. XXXIX. Fig. III. *b b*; for to exhibit them all, would require too large a drawing. Beſides the hairs already mentioned, there are here and there ſome other larger hairs, *c c*. All the variety of colours perceivable in this inſect, proceeds from this; that the colour of the grains is ſomewhat deeper or paler in ſome places than in others; for there is no material difference between them, in point of ſize. According, therefore, as the number of grains is greater or leſs, or the colour of them is darker or lighter, the furrows and rings are of a deeper or paler colour.

The head of this Worm, *d*, is, as it were, divided into three parts, and covered with a ſkin, the grains on which are hardly diſcernible. The eyes, *e e*, lie forwards near the ſnout, and are ſomewhat protuberant. It has likewiſe two little horns, *i i*, on the fore-part of its head. The ſnout itſelf is ſomewhat crooked, and ends in a very ſharp point, *f*; but what is altogether ſingular and ſurpriſing, and no doubt, if I may ſay ſo, is moſt wiſely contrived by the Great and Almighty Architect, is, that this inſect's legs are placed near the ſnout, between the ſinuſes in which the eyes *g g* are fixed: ſo that, at firſt ſight, I imagined this Worm made uſe of its ſnout, as Parrots do of of their bill, to faſten upon whatever it pleaſed, and move itſelf from one place to another; but I have ſince learned by experience, that thoſe parts are real legs, which is altogether as ſurpriſing as if a ſmall pair of hands, one on each ſide, ſhould be ſeen growing in a man from the inſide of his jaw-bones *.

Each of thoſe legs conſiſts of three joints; the outermoſt of which is covered with hard and ſtiff hairs, like briſtles. From the next joint there ſprings a little horny bone, *h h*, which ſerves the inſect for a kind of thumb: the joint itſelf is likewiſe of a black ſubſtance, between bone and horn in hardneſs; and ſo is the third joint. But theſe particulars cannot be ſo well diſtinguiſhed on the outſide; for which reaſon the parts that form the upper ſides of the mouth, and the eyes, muſt firſt be diſplaced with a very fine ſmall knife. This done, we may plainly perceive, by the help of a microſcope, that the leg is articulated by means of ſome ſingular ligaments, with that portion of the inſect's mouth, which anſwers to the lower jaw in the human ſtructure. We may alſo, by this method, diſcover the muſcles which ſerve to move the legs, and draw them quite up into the cavity that lies between the ſnout and thoſe parts of the mouth, near which the horns, *i i*, are ſituated.

I have taken the pains to draw five of thoſe muſcles adminiſtering to the inſect's leg, which are very diſtinct. Three of them, Fig. v. *a*, are continued by their tendons, in form of a black ſubſtance between bone and horn; and after this, growing ſofter, are inſerted *b* into the inſide of the greateſt joint of the leg, which is of the ſame kind of ſubſtance with the tendon. The other two muſcles, *c*, had their inſertions on the oppoſite ſide of the ſame joint. The muſcles which move the other joint, *d*, are inſerted into that large horny joint already mentioned; and in this joint alſo are to be ſeen the latent muſcles, which move the extreme joint of the leg, *e*, with its briſtles, and its thumb, which I here likewiſe repreſent, *f*. This figure ſhews, at the ſame time, in what manner the foot is ſurrounded with hair. This inſect not only walks with the legs I have been deſcribing, at the bottom of the water, but even moves itſelf on land by means of them. It likewiſe makes uſe of them to ſwim with, while it keeps its tail on the ſurface contiguous to the air, and hangs downwards, with the reſt of its body in the water. In this ſituation, no motion can be perceived in it, but what ariſes from its legs. At this time alſo it plies them ſo elegantly, that, to the naked eye, they appear like the vibrating tongues of Serpents. Hence we may conclude, that the greateſt ſtrength of this Worm lies in theſe parts; and we may be likewiſe convinced, that it exhibits in a ſingular manner, and more fully than many other animals, the wonderful contrivance and execution of the Divine Power and Wiſdom.

The ſnout itſelf, Tab. XXXIX. Fig. vi. *a*, is very black, and of a ſubſtance between bone and horn. This may beſt be ſeen by turning the inſect on its back: in this ſituation alſo we can diſcover the crooked point of the ſnout, *b*, near which the jaws open themſelves, *c*, and offer to our ſight the gullet or throat, and all the other parts of the mouth. Here likewiſe we may obſerve three membranaceous diviſions in the ſnout, two of them running tranſverſely, one at each ſide, *d d*; and the third ſtretched lengthwiſe between both: by means of theſe diviſions, aſſiſted by the muſcles contained in the ſnout, the Worm can at pleaſure expand or contract that part. But the back-part of the ſnout, *e*, is quite ſolid, and made up of a black ſubſtance between bone and horn, and of a rounded and ſomewhat globular form; whereas the ſharp part that lies forward, which I have before repreſented on the fore-part of the head, Fig. iii. *f*, is hollow.

The tail is moſt artfully imagined and conſtructed. Its extreme verge, or border, is ſurrounded by thirty hairs, and the ſides of them are adorned with others that are ſmaller. Here and there alſo, ſome of the bigger hairs branch out into others, each of which I reckon as a ſingle hair. Theſe hairs are all rooted in the extreme ſkin of the tail, which, in this place, is alſo covered with rough grains; as may be ſeen by cutting it off, and holding it up, when dry, againſt the light, upon a thin plate of glaſs. It appears likewiſe, by the ſame means, that the hairs of this part have, at their very extremities, grains alſo, like thoſe upon the ſkin; though I could never yet get a diſtinct ſight of them through the beſt microſcopes. In the middle of the tail is a little opening, within which there are two ſmall holes; by which the inſect takes in and lets out the air it breathes. It ſeldom happens, that the hairs of the tail are ſo regularly diſpoſed on the ſurface of the water, as I have here repreſented them, unleſs when the Worm but juſt floats with its body in the water, and the tail with the hairs belonging to it are a little lower than the ſurface; for then theſe hairs diſplay their extremities, in the diſtinct manner that I have here repreſented them: and the leaſt motion downwards of the tail, at this time, occaſions a conſiderable pit or hollow in the water; whilſt the tail itſelf aſſumes the figure of a glaſs, wide at top, and ending at the bottom in a point. Hence it is manifeſt, that this tail ſerves the Worm for both the purpoſes of ſwimming and breathing. Thus then, O wonder of wonders! this creature receives by its tail the univerſal principle of life and motion in animals. And the better to anſwer ſuch an important uſe, thoſe hairs are ſo myſteriouſly conſtructed, that, let them lie under water ever ſo long, they never contract any moiſture, the water running off of them the very moment they reach the ſurface. Another advantage the Worm has in theſe hairs, is, that, when ſwimming, it can by means of them immediately ſtop itſelf, and ſo remain quietly ſuſpended in the water as long as it pleaſes.

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* Theſe ſingular and amazing Worms are very common with us in ſhallow ſtanding waters. I found millions of them this year in a pond, in a field acroſs the road on the right hand of Liſſon-Green, near Paddington. They will live many weeks in a glaſs of water, and ſhew all their amazing qualities; confirming, in every inſtance, the accuracy and truth of this author's accounts. A microſcope ſhews very beautifully the motion of their inteſtines; and few inſects afford a more beautiful object.

CHAP. II.

Of the actions or motions of this Worm; the places where it is found, its food, and the manner of killing it for diſſection.

THE motions which this Worm makes in ſwimming are extremely beautiful, eſpecially when it advances with its whole body floating on the ſurface of the water, after filling itſelf with air by the tail. To ſet out in this poſture, it firſt bends its body to the right or left; then contracts it in form of the letter (S); and laſtly, or lying flat upon its belly, it ſtretches out the body again to a ſtraight line. By theſe alternate bendings, contractions, and extenſions, it moves along upon the ſurface of the water; and as its motions are very ſlow, it will hold out for a long time in this manner.

Theſe Worms are no way diſturbed on being handled in the water; though they cannot ſuffer the touch of other Worms, even thoſe of their own ſpecies, without agitation, when ſwimming amongſt each other. From this circumſtance we may conjecture, that they are provided with a ready inſtinct to diſcover whether what comes in their way is likely to do them any harm. Be that as it will, I drew great advantages from this quiet diſpoſition of the inſect, as it afforded me the better opportunities of examining it by the microſcope, and making a ſatisfactory figure of it.

At the time when theſe Worms float on the ſurface of the water, it is impoſſible to drive them under it, ſo as to make them continue there, on account of the great quantity of air with which they are then ſwelled. But on expelling this air by the tail, they of themſelves immediately ſink to the bottom; nor can they again make themſelves float on the ſurface of the water, till, having riſen to it, they expand the hairs of their tail, and take in another draught of air.

On taking theſe Worms out of the water, all their motion ſeems confined to the head, becauſe it is only by the help of their legs, which are ſituated there, that they can ſtir in this ſituation. But as it is neceſſary, for that purpoſe, that the head ſhould bend at the ſame time, one would, at firſt, imagine they make uſe of their mouth to walk with; whereas, in reality, their progreſs is entirely effected by the feet only.

Theſe Worms are to be found about the beginning of June, ſooner or later, according as the ſummer is more or leſs warm, both in ſalt and freſh waters. Sometimes great numbers of them offer themſelves, as it were, of their own accord to our inquiry; whilſt in other years, it is no eaſy matter to meet with them. They are common enough in the ditches of grazing grounds, eſpecially in ſuch parts of thoſe ditches as here and there contain little patches, or iſlands, covered with graſs and other plants, through which, and upon it, theſe Worms love to crawl. They are often too, to be ſeen in the cracks of our ditch-banks, where they float upon the ſurface of the water, by means of their tail, with head and thorax hanging down: and in this ſituation they will turn over the clay and dirt with their feet and their ſnouts, as thoſe parts are ſo near each other, in ſearch of food.

It is thus theſe Worms look out for their nouriſhment, which is principally a kind of viſcous matter, to be met with in little pools, and about the ſides of ditches; for theſe inſects are never ſeen in large and deep waters, ſo that, whenever it happens that the ditches are quite full, the Worms, to come at their food, either betake themſelves to the bottom, or venture on ſhore, in queſt of ſomething to live upon. It is very remarkable in theſe inſects, that, when they lie under water, they very often drive air into the cavity formed by the hairs of their tail; which cavity, on being thus blown up, looks like a tranſparent pearl moving in the waters; at the ſame time that, by becoming the lighteſt part of the inſect, it keeps uppermoſt, and thereby affords the feet and the ſnout a better opportunity of providing for the inſect's ſupport.

This little inſect is exceeding harmleſs; it neither bites or wounds, or otherwiſe does any miſchief; contrary to the opinion, one might at firſt ſight be apt to form of it, on account of the ſurpriſing vibrations of the legs, placed in its head, which ſo much reſemble the brandiſhings of an envenomed tongue or ſting: but ſuch notions appear altogether wrong on further examination; for the opening of the inſect's mouth, at which it ſucks in its food, is ſeated within the bending of its ſharp pointed and crooked ſnout.

I find that clay and ſoft earth are the food of this inſect; though I have likewiſe ſometimes found in it, on diſſection, little red ſtones, and ſmall grains of ſand intermixed: I am not able to explain, on account of the narrowneſs of this inſect's mouth, how it could poſſibly take in ſuch large and hard ſubſtances. This induces me to think, that it only ſucks in the ſubtile viſcous particles of earth, mud, and clay, which afterwards undergo various mutations in the ſtomach, as I ſhall hereafter endeavour to ſhew, in the anatomy of this Worm, and the Nymph produced by it, where I ſhall alſo relate the manner how the very inteſtines of this inſect caſt their ſkins.

I have tried many methods of killing theſe Worms, in order to examine them anatomically. Spirit of wine does not ſo well anſwer this purpoſe; for they live in it a day and night, or perhaps longer; but I cannot affirm any thing poſitively on this head, as I grew tired of waſting my time, that I could otherwiſe ſo well employ, in watching them. Some of them that I threw into rain water, after taking them out of the ſpirit of wine, together with others, continued alive ſeveral days, till I had opened them all, while living, in order to view their parts, and found myſelf under a neceſſity of looking out for a freſh ſupply. In vinegar alſo theſe inſects held out a long time, and they moved more briſkly in it, than in water; they would ſometimes alſo crawl out of it. Some of them endured this trial for two days and a night, and ſome a longer time, whilſt others expired ſooner. But hardy as their conſtitution may be, they die in ſpirit of turpentine in leſs than a quarter of an hour. It is very curious to obſerve, at this time, how the air contained in them remains, in appearance, fixed between their hairs, and the diviſions of their body, ſo as perfectly to imitate the appearance, as it were, of tranſparent ſilver.

The induſtrious Goedaert, as far as I can gueſs by his drawings, give us one of this Worm; as alſo a deſcription of it in the firſt part, and ſeventieth experiment of his natural metamorphoſis; but he forgets to tell us whether it belongs to land or water: nor is there among all his obſervations concerning it, any thing remarkable, except its being able to live for nine months without food. On this account he calls it the Chameleon, impoſed upon by the vulgar opinions of the land-animal of that name, living entirely upon air.

We have likewiſe, in the learned Aldrovandus, a figure and a deſcription of this Worm, under the name of the Water Inteſtine. But this author knew nothing of its changing to a Fly, or of the other ſurpriſing particularities, which I have obſerved in it.

CHAP. III.

The anatomy of this Worm, giving an account of its teeth, ſtomach, inteſtines, ſalival veſſels, pulmonary tubes, fat, heart, brain and muſcles.

THE internal parts of the Worm, which produces the Aſilus or Gad-fly, are the teeth, gullet, ſtomach, thick and ſlender inteſtines, ſalival veſſels, pulmonary tubes, fat, heart, brain, ſpinal marrow, nerves and muſcles; each of which I ſhall now ſeparately deſcribe. The teeth are ſeated in the back part of the mouth, as in many fiſhes, ſo as to enable the inſect, after it has taken in any food, to grind it properly before it gets down into the ſtomach. I have by me ſpecimens of Hermit-fiſh, and large Crabs, which have teeth in the very cavity of the ſtomach. The teeth of the inſect now under conſideration, are of a ſubſtance between bone and horn, and their ſurface is in many places rough and unequal; but theſe aſperites are not conſiderable enough to be taken notice of in the figure. The gullet is a very ſlender channel, running from the jaws and mouth to the ſtomach, through a fiſſure or opening in the ſpinal marrow, contrived on purpoſe to give it free paſſage: this is likewiſe the caſe in many other inſects. For this reaſon, the brain of this Worm lies, as it were, upon the fore-region of the ſtomach. The ſtomach itſelf appears as a ſmall membranaceous particle, and is found full of the half-digeſted food, on killing the Worm, in ſpirit of turpentine, as ſoon as it is caught, and then diſſecting it. The ſlender inteſtines alſo appear, on this occaſion, filled with the ſame ſubſtance. In this ſpecies of Worms, the ſtomach and ſlender inteſtines are about five Dutch inches in length; or to uſe Mr. Thevenot's method, they are equal to five rows of regular cells of Bees, built one againſt another, five in a row. Mr. Thevenot imagined, that by means of ſuch cells, an univerſal meaſure for all nations might be diſcovered, ſuppoſing ſuch cells were every where equally regular, and of an equal bigneſs. I muſt here obſerve, that there is very little difference between the ſtomach and inteſtines of this inſect.

Towards the extremity of the ſlender inteſtines are four vaſcula varicoſa, or cæca, or little guts or appendages cloſed at the end: theſe are ſituated equally in the abdomen and thorax, which ſometimes contain an aqueous fluid, and ſometimes a bright white ſubſtance, like coagulated milk or new cheeſe, when beginning to crumble to peices. Theſe four little inteſtines are full twice as long as the real guts of the creature, and they form a great many uncommon turnings and windings in the thorax and abdomen, ſo that it requires no ſmall pains and attention to diſcover and ſeparate them. In the next place are the large inteſtines, which here and there ſwell out into nodules, as it were, and are filled with clay, red particles of ſtone, grains of ſand of different ſizes, and other ſimilar ſubſtances. All theſe particulars will appear to greater advantage in the figure which I propoſe to give of the Nymph's inteſtines, accompanied with a deſcription of the nature of the ſand or gravel which are found in thoſe parts.

The ſalival veſſels, Tab. XXXIX. Fig. VII. *a.* are two channels, cloſed at their ends. They are of a membranaceous tranſparent ſubſtance, and are ſeated in the thorax, where they make a great many windings and turnings. In colour they reſemble freſh curds, on account of their contents which appear through them; and accordingly, on their being cut, nothing freely flows from them, the matter they contain being quite coagulated. The ſalival veſſels unite at laſt, ſo as to form only one, *b,* which terminates at the mouth, to which it is inſerted upon in the back part of it. Near this inſertion appear two ſmall particles, *c c,* which very much reſemble little muſcles. As I never met with any fluid matter in the veſſels I have been laſt deſcribing, I cannot take upon me to ſay any thing poſitively, concerning the uſe which the Worm may make of them, though I called them ſalival veſſelves, becauſe ſuch channels are very remarkable in other Worms, and alſo in ſnails. They appear even in the Nymph of the Worm now before us, and afterwards in the Fly, in which they are ſtretched out to their full length, and after pervading the thorax, they terminate in the abdomen, being remarkably broad at their extremities, if compared with their condition, as they were in the original Worms; this makes me believe, that theſe veſſels do really, at laſt, perform in the Fly, the office of ſalival ducts. The mouth, Fig. VII. *d,* at the bottom of which thoſe ſalival ducts terminate, is here repreſented without the eyes, becauſe, in diſſecting this Worm, both the eyes, and thoſe parts which conſtitute the ſides of the head, very eaſily ſeparate from the mouth.

There is no part of this Worm without its pulmonary tubes *. They conſiſt of two very conſpicuous and conſiderable tubes, Tab. XL. Fig. I. *a a,* which are compoſed, as it were, of flattiſh rings, and are much wider in the middle than at the back or fore extremity, which runs towards the tail. Theſe tubes are ſeated on the ſides of the inſect's body, where they unite with the puncta reſpiratoria, or breathing holes. It is probable, however, that the inſect does not make uſe of them for breathing, till it is arrived at the Fly-ſtate, when it lives in the air; ſo that theſe channels remain cloſed, till the inſect comes to live in another manner, juſt as the aſpera arteria of a fœtus continues cloſed, as long as it lies in the amnion, and ſurrounding waters. The pulmonary tubes are diſtributed all over the body; they even penetrate the bowels, brains and nerves, in order to ſupply every part with this vivifying fluid. Great multitudes of them are to be ſeen in the ſame place with the optic nerves, and the increaſing membranes of the eyes, *b,* and they gradually enlarge, in order to contribute to the formation of eyes in the Nymph, and afterwards anſwer all the purpoſes of ſuch parts in the Fly. Here and there theſe tubes meet, and unite together from the parts, *c c,* eſpecially about the ſides of the body, *d d d d d d,* where one may perceive a general anaſtomoſis of them one with another, by means of their common intermediate branches, ſtretching from one breathing hole to another; from hence ſpring an infinite number of ramifications, adminiſtering to the membranes and muſcles of the ſkin, which I here mark with points, *e e e e,* and likewiſe to the internal parts. At laſt, the principal channels end at the feet, *f,* by two diſtinct tubes opening into one paſſage, where they ſerve to take in air for the creature's uſe, and alternately expel it, as has been already ſhewn in the external ſurvey of that part, as the ſaid tubes appear very plainly through the tranſparent ſkin of the inſect.

The largeſt of theſe pulmonary tubes are ſufficiently conſpicuous; and they are compoſed of crooked rings, and are alſo ſomewhat flat, as I already mentioned, Tab. XL. Fig. II. *a a.* On ſtretching a piece of theſe tubes, thoſe rings which compoſe them, ſeparate very readily, ſo as to roll out to the length of two or three ſpans, and then they look very pretty, being like an extended ſcrew, or an untwiſted ſpiral, or a ſilver wire that had been wound up upon a needle, *b.* This ſilver-like thread, of which the rings are formed, is almoſt as ſtrong as the thread ſpun by the Silkworm, on breaking, it ſnaps with a crack that is very perceptible.

The fat, Fig. III. *a,* is diſtributed all over the Worm's body, ſo as to be met with in the head, as well as in the abdomen and thorax. It is as white as the pureſt ſnow, except at the tail, where it generally inclines to be a little green. As to its textute, I don't well know how to deſcribe it, on account of the ſtrange variety, in point of configuration of the particles that compoſe it; for they are round, *b,* oblong, *c,* broad, *d,* angular, *e,* pyriform, or in the ſhape of a pear, *f,* and of almoſt every other imaginable ſhape. This fat is moſt firmly united with the pulmonary tubes that run through it, *g;* ſo that I believe it ſerves, in the ſame manner with the Omentum or Cawl in man, to bind together the blood-veſſels, and convey them in ſafety to their ſeveral deſtinations. This fat, if laid on a piece of glaſs, and held to a candle, melts like oil, and immediately flames; this proves, that it is really what I have called it. Theſe particles, in regard to the veſſels contained in them, might be called vaſa adipoſa, or fat veſſels; but ſuch a name would be improper for them. This fat in the Nymph and Fly, retains nothing of its original form, as may be ſeen by examining it in the Worm where it exhibits ſo entertaining a ſight, that it is impoſſible for words to give a juſt idea of it.

Not only the form of the heart, Fig. IV. *a.* in this Worm, but its pulſations alſo may be ſeen through the ſkin, under the third ring, counting from the head; but this is a great deal more perceptible in the Nymph, when ſtripped of its outer covering; for at that time the motion of the heart appeared to me ſo plain, and was withal ſo conſiderable, that I ſaw it diſplace a particle of fat in one of its vibrations. The end of this powerful organ, when it is faſtened to the tail, is a little ſharp and narrow, but here and there it dilates itſelf, Tab. XL. Fig. IV. *aa*. Towards the head it gradually widens *bb*, and then cloſes again into a narrow channel *c*, in which form, after paſſing through the abdomen and thorax, it purſues its courſe towards the head, where it is intimately united with the membranes of the brain. Thus, in regard of figure, the heart of this Worm nearly repreſents the Worm itſelf, except the part next the head, being a great deal narrower, and that next the tail, dilating itſelf here and there, as in Silkworms.

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* The number of theſe pulmonary veſſels in the generality of inſects is aſtoniſhing, and it is ſo alſo in plants. They not only appear conſpicuous in all parts of them, but the greater part of the ſtalk in May is compoſed of them; this is particularly obſervable in the ſtalks of bulbous plants: and in the ſame manner we ſee it in the inſect-tribe moſt plain, and the tubes moſt numerous, and divided in the ſofteſt ſpecies.

On opening either the Worm or Nymph, the motion of the heart preſently ceaſes; and if it did not, the particles of fat with which it is ſurrounded, would hinder us from ſeeing it. For this reaſon, the beſt time for examining the heart of this inſect, is when it has attained the Fly-ſtate: or if we chooſe to do it in the Worm, we ought firſt to leave it for ſome time in ſpirit of wine, that the fat may gradually diſſolve and waſte away; but at this time, the heart is ſo delicate as not to ſuffer any air to get into it. In the beginning, I really thought I ſhould never be able to diſcover or diſcloſe this part; and I muſt own, that human ignorance and weakneſs never appeared ſo evident to me, as during my ſurvey of this little inſect; for with all my attention and diligence, I found it impoſſible to examine it as minutely as I propoſed, tho' I ſpared no time to get the better of all the difficulties that oppoſed my inquiry; the wonders I diſcovered in it, being but a ſmall part of thoſe accumulated miracles I have here related. This my inſufficiency has made me very often, in the courſe of my inquiries, break out within myſelf into the following words:--- O God, thy works infinitely ſurpaſs the reach of our feeble underſtandings; all that we actually know of them, or ever can know, is but a faint and lifeleſs ſhadow of thy adorable perfections. The brighteſt underſtandings fail in the contemplation of them, and are obliged to confeſs, that all this boaſted penetration is but ſhort-ſightedneſs, when employed in fathoming the depths of that power, goodneſs, and wiſdom it has pleaſed thee to exert in the loweſt parts of thy creation!

The truth of theſe words evidently appears by the conſtruction of the brain, ſpinal marrow, and nerves of the Worm here under conſideration, which I am now going to deſcribe; for this conſtruction is ſo wonderful, that I doubt very much, whether any thing equal to it was ever before obſerved in any animal. The brain conſiſts of two globular lobes, Tab. XL. Fig. V. *aa*. Theſe lie upon the gullet; and for this purpoſe nature has contrived a ſlit *b* in the ſpinal marrow for the gullet to paſs through. On the forepart of the head appear the membranaceous parts of the eyes *cc*, which gradually expand themſelves along with the optic nerves that are to ſerve the ſucceeding Fly, and grow till they are arrived at their juſt period of increaſe. In the mean time, theſe membranaceous rudiments of the Fly's eyes are curled and folded up, and cannot be ſeen but very imperfectly, becauſe the inſect has not as yet attained its Nymph-ſtate, in which at laſt all theſe parts unfold themſelves, and become very diſcernible.

The ſpinal marrow conſiſts of eleven nodules *dd*, which form the moſt elegant ſpectacle that nature ever exhibited; for it is bent ſo as to reſemble a ſwine's tail, and runs as it were in curls from one end to another. This curling may be ſtill conſiderably increaſed by cutting the nerves. The figure I give of this part does not expreſs all the windings of the original, the better to exhibit the eleven nodules, from whence all the other nerves take their riſe; for all the nerves of the inſect ariſe from the brain, the ſpinal marrow, and theſe nodules. In the firſt place we are to name thoſe nerves which tend to the forepart of the head, and running under the membranaceous rudiments of the future eyes *ee*, are diſtributed to the gullet, the jaws, the mouth, and palate, to the Worm's eyes, the muſcles of the legs, and parts thereabouts. Next are the nerves *f* which extend to the ſides of the inſect's body. Laſtly, there appears a conſiderable number of them *gg*, that ſpring on each ſide from the eleven nodules of the ſpinal marrow. To avoid confuſion, I have omitted ſome of them in the figure; the laſt mentioned ramificatiens go to the ſtomach, inteſtines, muſcles of the ſkin, and all the other internal parts, which they ſupply with motion, ſenſe, and life. But how is it poſſible to deſcribe the ſpirits contained in thoſe nerves, and the manner in which the ſecretion of ſuch ſpirits is performed? For my part, I freely acknowledge, that as yet I have not been able to diſcover for what purpoſe the medulla ſpinalis is curled up in this inſect, while a Worm, in ſo ſtrange, but elegant a manner;* whereas in the Nymph, and afterwards in the Fly, though neither of them are ſo long as the original Worm, it appears ſtretched out to its full length. It is in the eleven nodules that the alteration is moſt conſiderable, for theſe in the Nymph and Fly (O incomprehenſible wonder!) are found at a greater diſtance from each other, than they were in the Worm. The nerves, on the contrary, from lying at full length in the Worm, are curled up and folded in the Nymph and Fly, and are otherwiſe altered in a moſt ſurpriſing manner, as I ſhall hereafter explain by a figure of the Fly's ſpinal marrow. The tranſmutation, therefore, from a Worm to a Fly, obſervable in this inſect, preſents us with a real miracle, and may juſtly be conſidered as a laying down of old worn-out parts, and an acquiſition of new perfect ones inſtead of them: in fine, as a total change of an old to a new, and of an imperfect to a perfect body, infinitely ſurpaſſing the utmoſt ſtretch of human underſtanding, as on reading and attentively conſidering the hiſtory now before us plainly appears. As for my part, I dare boldly affirm, that the incomprehenſible greatneſs of the Deity manifeſts itſelf in theſe myſterious operations in a particular manner, and affords us an opportunity of examining, as it were, with our ſenſes, the Divine nature.

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* As important as the ſpinal marrow is to the animal œconomy, we find that it does not obſerve the ſame courſe in all creatures. In the generality of animals it runs through the middle of the back-bone; but in fiſhes in general, it is carried through certain peculiar apophyſes ſituated on the upper part of the vertebræ: we ſee in how ſtrange a manner it is diſpoſed in inſects. There cannot be a better ſubject of inquiry for the naturaliſts, than into the reaſons of this various cauſe, and the purpoſes it anſwers.

If thoſe authors, who invented a metamorphoſis, in order to ſolve the difficulties that occur in the hiſtory of inſects, had ſeen the wonders I have been juſt relating, it is probable, that they would have made arguments of them to ſupport their erroneous opinions; tho' the inſect itſelf, notwithſtanding all its changes, conſtantly continues one and the ſame, and like a chicken, attains to a greater perfection, by a mere gradual increaſe of its parts, and no otherwiſe; for even the parts themſelves always remain the ſame, whatever alterations we may obſerve in their figure. What I here affirm of the parts, holds true even at the time when they fall off or diſappear, in order to make room for others which ſprout out to ſupply their places.

Job, in like manner, ſpeaking of the reſurrection of his body, ſays, "with theſe eyes I "ſhall ſee God."

Nevertheleſs, I ſhould be ſorry, that any one were weak enough to imagine, that theſe our mortal eyes, which are but duſt and aſhes, and as ſuch are condemned to putrefaction and decay, are ever to appear in the ſight of God. By no means; the body we now carry, is but the ſeed or egg, as it were, in which another more noble body lies concealed; and of this myſtery the Worm we are treating of affords a moſt ſatisfactory example; as it might very juſtly ſpeak of its eyes, as it were, in the following manner: With theſe, my eyes, I ſhall raiſe myſelf on high, ſoar up to the ſkies, look down upon the fields, and dart with rapidity through the air, in praiſe of my maker. Thus, I ſay, this Worm might boaſt of its eyes in words, which however are far from being true, except in reſpect of that perfection which the eyes are afterwards to attain; on the inſect's changing to a Fly; for then they are to be increaſed in number, otherwiſe ennobled, and ſhall enjoy a ſight more perfect than the former, as I have already ſufficiently demonſtrated in the eyes of bees.

The moſt conſiderable muſcles of the Worm here treated of, are in general placed in the head: of them I have deſcribed and delineated only thoſe which ſerve to move the feet. Moreover, in the thorax alſo, the belly and tail, are ſeen a great number of muſcles, which being extended from one of the annular inciſions to another, move the body various ways, by means of fibres formed and diſpoſed in a variety of manners. But as theſe muſcles do not remarkably differ from thoſe which I have deſcribed in other inſects, and which have been repreſented in the preceding figures, I need ſay nothing of them farther, until I come to the Fly itſelf. I ſhall therefore cloſe here the preſent chapter; adding only, that the limbs are ſometimes diſtorted in this Worm; ſo that its body is found really crooked and bent: and hence we are taught, that theſe inſects are liable to the ſame calamities that other animals are ſubject to by the law of nature. It is, however, worthy of notice, that when I viewed a diſtorted or deformed Worm, of this ſpecies, when changed into a Fly, it was no way deformed; its body being then perfect after its change, or rather its reſurrection.

CHAP. IV.

The wonderful manner wherein this Worm paſſes into a Nymph; and of the parts that are ſeen in the Worm, when it is ſtript of its ſkin; and the ſame parts afterwards clearly ſhewn in the Nymph.

THE Worms here deſcribed, are at length changed into Nymphs of the fourth order, when their limbs and other parts are ſufficiently grown under the ſkin. When they are about to change, they betake themſelves to the herbs that float on the ſurface of the water, and creep gently thereon; until at length they lie at reſt, partly on the dry ſurface, and partly on the water: if they are about that time driven off into the water by force of the wind, or if they be kept in a little veſſel filled with water only, yet their change is not on that account impeded. But when they afterwards, under the form of a Fly, iſſue out of the habit of a Nymph, then indeed they are very eaſily ſuffocated in the water; as long as theſe little inſects are Worms, they can conveniently live in water, but by no means when they are changed into Flies. Indeed, man alſo, whilſt in the uterus, lives in the water of the amnion; but he can by no means do this afterwards, when, by breaking open the membranes, he is brought into the world. Therefore theſe Worms, lying in their natural ſituation, always ſeek after the floating herbs, wherein at length they lie at reſt; and then they, by degrees, contract themſelves, and in a manner ſcarce perceivable, loſe all power of moving.

Then the inward parts of the Worm's tail inſenſibly ſeparate from the outmoſt ſkin, and become greatly contracted: and this perhaps does not happen without pain to the creature: for this external ſkin is then commonly gathered into three, and ſometimes into four windings, Tab. XLI. Fig. 1. *a a a*, and its extremity is left like an empty ſpace, into which the air penetrates, and ſoon fills the place which the body had before occupied, but has now left vacant by contracting itſelf. If this void ſpace be not filled up by the ſucceeding air, the ſkin of the tail becomes curled into itſelf: but this I obſerved only once.

Thus this inſect is by degrees changed within its own ſkin, nor does it before this time caſt it, or is it outwardly altered into a conſpicuous Nymph; ſo that this order of tranſmutations is entirely different from that obſerved in ſilk Worms, and other innumerable ſpecies of inſects.

I have often ſeen this Worm, in the ſpace of twelve hours, that is from ſix in the evening to ſeven in the morning changed, into a Nymph. And all theſe things are performed in a hidden, obſcure, and unknown manner, inwardly within the ſkin, which lock them up, as it were, from our view. For this reaſon, this ſpecies of metamorphoſis has been tortured, as a thing ſo monſtrous and incomprehenſible by thoſe, who, like the dog in Egypt, look only in a ſlight aud curſory manner into nature *.

When the Worm, which is thus to be changed, has a ſoft ſkin; that ſkin neceſſarily accommodates itſelf to the changes and contractions of the internal and inviſible body of the Nymph. And hence it happened, that even the moſt learned, who have wrote on this ſubject, have not ſcrupled to give theſe inſects the name of eggs: in which indeed they have committed a very great error, and corrupted the natural miracles and truths of God. Thus they think and inſert, that one inſect is changed in this inſtance into another; nay, that it again becomes an egg; and that the egg is afterwards changed into a Fly, by a raſhly imagined abſolute metamorphoſis: others add, that all theſe things are produced by chance, and from putrefaction: and this indeed is the ſhort path to atheiſm. For, if the generations of things be ſo ſubject to chance, what prevents man from being thus as eaſily produced in the ſame manner? This alſo ſome have not ſcrupled to declare in their writings. God is certainly as admirable in the ſtructure of inſects, as in that of man. The body of a beaſt deſerves as great admiration as the human body, if we conſider both in their kind and nature. Both far ſurpaſs the ſphere of our inquiry: both are incomprehenſible and impenetrable; ſince innumerable divine miracles are contained therein.

Whilſt this Worm therefore is changing within its ſkin, the body, head and tail inſenſibly ſeparate from the outmoſt inveſting ſkin. The legs alſo about that time, and their cartilaginous bones, are, by reaſon of the joints, drawn back from them, left intirely empty within; and hence they are drawn backward or inward to the orifice of the mouth, and there they lie unmoved. The Worm at that time alſo loſes all its ſkull, and the beak, together with the horny bones belonging thereto; for all theſe remain fixed in the ſkin of the head. From thence it afterwards draws its horns, its trunk, and other parts, which are there inwardly increaſed, and are afterwards to be ſeen in the Nymph.

A matter worthy of great notice here, is this: the optic nerves ſeparate alſo from the eyes, and no more perform their former office. The muſcles of the rings alſo in like manner, and a great part of the pulmonary points of reſpiration are ſeparated from the external skin. Thus the whole body contracts itſelf by degrees, into a ſmall compact maſs.

But the greateſt change is obſerved in the hinder part about the tail: for there the body, having quitted, Tab. XLI. Fig. *b*, *c*, *d*, its three extreme rings together, riſes up into the fourth, *e*, and ſometimes even to the fifth ring. Therefore, if you view, in the light, the Worm, which hath been for ſome time changed; you will very diſtinctly, and without the aid of diſſection perceive, that its hindmoſt rings are empty, or are only filled with air: this is likewiſe, though more obſcurely, obſerved between the head, and the ſecond ring *f*. But the place which the Nymph, encloſed within poſſeſſes, then appears black, *g*; becauſe it does not tranſmit a ſufficient quantity of the rays of light.

At this time the gullet too, the inteſtines, and the pulmonary tubes in a manner caſt a coat within the ſkin: this indeed is alſo very ſingular, and amazingly ſhews the miracles of God; teaching at the ſame time, how the former body is entirely caſt off and renewed. In order to make this evident, it is neceſſary to open the ſkin of the abdomen: after this the Nymph, Fig. II. *a*, and its parts, together with the caſt, pulmonary pipes, *b b*, will manifeſtly preſent themſelves to view: nay, it will likewiſe be ſeen, how the Worm hath caſt off, *c*, all the parts of its head and beak, and is became entirely immoveable, except in the tail; by means of which it ſtrongly moves, agitates, and draws itſelf back even to the fifth ring of the body.

The whole Aſpera arteria about that time caſts its ſkin on each ſide. For, as this conſiſts of two remarkable tubes; therefore they are firſt turned out of the body, whilſt the Worm is contracting its tail, and are left ſticking in the empty ſkin, as I ſhall more clearly deſcribe, when I come to explain the method whereby the Worm, when changed into a Fly, breaks forth out of its ſkin; for it then draws the exuviæ from the other pulmonary pipes.

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* The hardneſs of the exterior ſkin, in this and many of the other Worms which change into Nymphs, under a covering of their own outer ſkin, which forms a kind of ſhell, makes it appear ſtrange, that ſo feeble a creature as the young Fly can get out. But nature has provided for this. There is always a weak part of this ſhell, where the head of the Fly lies: there are certain ſutures, at which it may eaſily be burſt open: and the means ordained for theſe, are the ſwelling and ſubſiding of the creature's head. This becomes inflated like a blown bladder, and then ſhrinks down again at repeated intervals; and theſe motions burſt the ſhell.

In order to place theſe truths the more evidently before our eyes, we muſt very cautiouſly draw the Worm out of its ſkin, at the time when it begins to harden or grow ſtiff; for, ſince this Worm is not yet in reality become a Nymph, but has all its parts diſpoſed in a different manner than in the Nymph; we may ſee each of them in its place, and where they are reſpectively ſituated in this ſtate in the head and tail. Thus I exhibit, Tab. XLI. Fig. III. *a a*, the antennæ or horns, the head, *b*, which I have delineated ſomewhat too large; under the latter is ſeen the proboſcis or trunk, and on each ſide the firſt pair of legs, *c c*; beneath theſe appear the wings, *d d*, and then the ſecond, *e e*, and third pair *f f* of legs. Then follows the abdomen, *g*, with its rings, and then the tail, *h*. In the abdomen are very diſtinctly ſeen tranſparent particles of fat; and in the tail, the pulmonary tubes come in view, diſplaying, or rolling out themſelves, *i i*. It further appears how even the inteſtines, *k*, caſt a ſkin; for they remain fixed to the orifice of the fundament, which opens in the utmoſt part, and is here cut off from the ſeparated ſkin, *l*; for the Worm does not diſcharge its excrements through the extremity of the tail, but ſomewhat higher, where we may likewiſe ſee the fundament.

What I have hitherto advanced, may be ſeen more evidently in the Nymph; in which theſe parts are diſpoſed in their natural order, and ranged beautifully and artificially among themſelves. Here then occur the antennæ, Fig. IV. *a a*, with their joints: the eyes, *b b*, which are now arrived at their full ſize: the proboſcis, *c*, and its appendages, ſituated under the eyes on the breaſt: the firſt pair of legs beautifully folded, *d d*; behind theſe are likewiſe ſeen another pair, *e e*: under the latter, again appear the wings, and their artificial convolutions and beautiful foldings, *f f*. The body likewiſe exhibits its annular diviſions to view, *g*. Under the ſecond pair of legs, the third pair likewiſe exhibits itſelf, *h*. Thoſe black ſpots alſo that are ſeen on the body, and which we ſhew to be ſituated in the Worm, above or over the points; the pulmonary pipes, are here likewiſe very diſtinct *i i*. But near them are alſo preſented to our view four apertures of the pulmonary tubes, *k k k k*, and alſo the annular inflexions of the body, with ſome ſmall prominences, there ſtanding above the ſurface of the body, which have alſo caſt their ſkin. The claws are tranſparent in the extremities of the feet; and make a beautiful figure, when the Nymph, being ſome days old, has loſt the greateſt part of the ſuperfluous humours by evaporation, and in the integuments or covers of the membrane, wherein it is inveſted, and in its outmoſt ſkin in which it is involved, like a tender birth newly brought to light, becomes by degrees ſtronger and more firm; ſo that at length it is able to creep abroad, and break open and caſt off both its coats at the ſame time: that is, this Nymph is covered with two integuments; whereof the interior is a thin membrane, which very cloſely inveſts the Nymph: the other, or exterior, is conſtituted by the outmoſt hard ſkin, within which the little inſect has performed its change in an inviſible manner. This is the ſkin which makes this inſect look like a Worm at this time; and it is this ſame ſkin which made me give this order of changes, the name of a Vermiform-Nymph.

Whoever therefore deſires to have a thorough knowledge of theſe creatures, muſt treat them in all theſe ways. I have obſerved, that in thoſe Worms, which I had newly drawn out of the ſkin, one might diſtinguiſh plainly the mouth and the points of reſpiration; even more clearly than in the Worm that is ſtill, creeping, ſwimming, and is no way changed. Indeed, had I not reſolved to be ſuccinct in this place, I ſhould deſcribe what has been hitherto ſaid much more at large, and ſhould have delineated all the parts, and at the ſame ſhewn their ſituation in the Worm; as alſo what pellucid little parts are obſervable therein, what their ſtructure is, their motion, how the pulmonary tubes are inſerted, and much more; but I am obliged to be ſparing of my leiſure hours.

CHAP. V.

The anatomy of the Nymph, the fat, the pulmonary tubes, the ſtomach and inteſtines: the wonderful changes obſervable in the ovary, muſcles, ſpinal marrow, and other internal parts which inſenſibly come in ſight.

THE Nymph I examined being freſh ſtript of its integuments, was of a bright green colour, with white tranſparent, and ſome greeniſh particles of fat: and indeed it made a beautiful appearance; eſpecially as the pulmonary tubes were at the ſame time obſerved to glitter like pearls. The head, the legs and wings were ſoft and fluid like water, and when but very lightly touched, they immediately diſcharged an aqueous humour. The pulmonary tubes had become conſiderably ſmaller, narrower and more contracted. From the tail unto the place, next below the wings, I counted ſeven apertures of the lungs; all which, as well as the rings of the body being cloſely gathered up above each other, differed very much from the points of reſpiration in the Worm; ſo that therefore the Nymph was now only one third as big as the Worm had appeared to be before.

If this Nymph be laid on its belly, the heart is immediately ſeen beating in its back, without any previous diſſection: this indeed appears very rarely ſo after the inciſion of the ſkin; becauſe the heart then, by reaſon of the guſhing out of the blood, which is aqueous, and like an ichor, preſently ceaſes its palpitation. Immediately under the ſkin are ſeen alſo the muſcles appointed for moving the rings of the abdomen. The next thing that comes in ſight is the fat: this was not much changed here; but, upon viewing it in a more adult Nymph, I found it ſo wonderfully altered, diminiſhed, and extenuated, that I thought I ſaw not fat, but a parcel of eggs: that is, its former oblong, angulated, broad particles, were now become almoſt round and globular, Tab. XLI. Fig. v. *a.* Beſides, alſo, it loſt ſo much by the evaporation, and contracted itſelf in ſuch a manner, that its diminution indeed was very conſiderable. Hence it muſt neceſſarily follow, that the body, on account of the great plenty of the waſted fat, muſt become more contracted, and poſſeſs a ſmaller ſpace than before. The colour of this fat inclined to purple; but in the hinder part of the belly it was entirely green. Thoſe particles of fat adhered to each other, and alſo to the pulmonary pipes, *b b*; ſo that, when I touched them with a fine ſharp-pointed knife, made like a lancet, they parted from each other with the leaſt motion. In the Nymph that was very newly changed, the fat became more green.

In the ſtomach and inteſtines alſo is obſerved a very great and wonderful change. This, however, is more or leſs obſervable, in proportion to the quantity of the Nymph's ſuperfluous fluids which have exhaled, and as the internal humours have been more or leſs diſſipated. Hence it cannot, indeed, be deſcribed how much the inteſtines are, by reaſon of their habit and figure, altered, dilated, or contracted; that is, according as the ſuperfluous moiſture is more or leſs expelled by perſpiration. Among all the remarkable changes which I have obſerved in theſe parts, I ſhall exhibit that which, in my opinion, is the moſt beautiful, and ſhall begin a deſcription of it from the gullet, Tab. XLI. Fig. vi. *a.* The gullet is here obſerved to be placed out of the horny parts of the head, *b,* back, and contracted legs. It appears alſo how this gullet paſſes *c* through the aperture of the ſpinal marrow, under the brain, and extends itſelf *d* unto the ſtomach. The ſuperior or upper part of the ſtomach is alſo found to be contracted, as it were, into five annular ſmall rugæ, or folds, through which the pulmonary tubes run very beautifully: and hence, on account of that contraction, it cannot be there ſeen how the ſtomach is circumſtanced on the inſide. A little lower, it exhibits quite another face; for it is divided by oblong grooves or furrows, which, in the figure, I have marked *e* with points. But as the ſtomach is there likewiſe inflated, and filled with a limpid humour, it is therefore obſerved *f* to be like an open tranſparent tube in this part; and it is the more conſpicuous, as it is in colour ſomewhat red. But it is neceſſary to obſerve, that the part of the ſtomach, juſt now deſcribed, eaſily ſeparates from the next inteſtine. The beginning of this ſmall inteſtine is very beautifully ſinuated, or bent, in like manner as the ſuperior or upper part of the ſtomach, with ſix foldings, or, as it were, corrugated convolutions, *g.* Afterwards, within this inteſtine, is diſcovered another ſmaller inteſtine, *h,* which, being contained in its cavity, and curled with many windings, wonderfully twiſted, deſcends, *ii,* and again terminates underneath, in an open extremity.

This little inteſtine is of a bright yellow colour, and appears very plainly through the larger inteſtine; becauſe the fluid, which is in that part of this inteſtine that comprehends it, is limpid and perſpicuous. If that ſmall inteſtine be wounded, the little inteſtine, contained in it, may be drawn out almoſt twice as large as it appeared in the cavity of the larger. Then it is manifeſt, that the yellow colour, wherewith its ſurface is diſtinguiſhed, proceeds from the yellow fluid contained in it. What the uſe of this little inteſtine is, is impoſſible for me to explain: in this reſpect, the works of God are impenetrable. Nor ſhall I, indeed, ſcruple to aſſert here, that not even one truth, in reſpect to the actions of the parts of animals, or even of the human body, is hitherto fully and clearly known to us. Indeed, thoſe who think the contrary, acquieſce in imaginations, taking them for facts. From my own obſervations I ſhall here add one thing, that is, that I have found this little inteſtine in the gut of the Worm now preparing to undergo a change: and this is the reaſon which induced me to attempt delineating the head of the Worm to the gullet, though I there repreſent the parts of the Nymph. I once found that inward little inteſtine in an old Nymph: it was there very brittle, and at the ſame time ſomewhat more red, and in a condition as if it began to waſte away. And hence it likewiſe ſeems evident, why I have not afterwards found it in the Fly. Indeed, in thoſe Flies, which are very juſt excluded, I have ſeen that this little inteſtine has been abſolutely conſumed. Wherefore one may probably conceive, that this little inteſtine is the inward coat of the ſmall inteſtine in the Worm; and that this coat, not being caſt out whole and entire, is by degrees conſumed in the body. But theſe are only my own conjectures. I remember I have ſeen ſuch little parts in Spiders too. I likewiſe find, that Thomas Willis, that celebrated member of the Britiſh Society, obſerved one inteſtine in another in the Earth-Worms. And ſince I here treat of the inteſtines, I cannot help taking this opportunity of complaining of the ingratitude of Caſparus Bartholinus, junior, towards me: for he, though I had, out of good-nature, ſhewn him all the more uncommon preparations and ſpecimens, which I had procured by the help of different anatomical contrivances; yet, in revenge that he did not ſo far ſucceed as to make me communicate the ſeveral methods to him, and being full of indignation, he has not ſcrupled to object to my propoſition, whereby I affirmed that I would ſometime reſtore the certainty of the office of ſanguification to the liver. With what eyes has this lyncæan author, who, in the front of his book, aſſumes the bombaſt title, *Aut Cæſar, aut nihil*, i. e. a man, or a mouſe, diſcovered my thoughts ſo far as to know, that I had only one experiment for this purpoſe? Indeed, my anatomical preparations, which he ſo much admired, could and ought ſufficiently to have taught him, that I have not advanced that theſis raſhly, or without important experiments. I would therefore adviſe him to contain himſelf yet, and temper his gall with water, until I have leiſure, and a more convenient opportunity, to treat this ſubject, and ſolve the ſeveral doubts which I have ſaid hitherto occurred to me. I ſhall then ſhew the experiments, and aſſign the reaſons, which confirm me in this opinion. And theſe are the very words, wherein I propoſed to the public the ſaid theſis, in my notes on the Prodromus of the famous Hornius. But he that is bent on revenge, has in view only the monſtrous images of his own thoughts. In the mean time, however, as I have there mentioned experiments and reaſons, this raſh young man might have concluded from thence, that I was provided with more experiments, to demonſtrate this theſis, than that trifling one, which I really do not acknowledge to be mine, in the place above cited. Nay, I join with this good-natured Bartholinus, who, like a Butterfly, has yet ſcarce crept out of his Chryſalis, that the experiment, conſidered by itſelf, contributes nothing to ſtrengthen my theſis: ſo that it therefore appears, that he would refute what he himſelf does not underſtand, and perhaps is not capable of underſtanding. But I return to my hiſtory, which I hope will be more uſeful than a controverſy of this nature. In treating this ſubject hereafter, I ſhall only explain what is pertinent to the matter itſelf, leaving altercations to thoſe who love them.

Below the place where the little inteſtine, before deſcribed, is ſeen within the inteſtine of the Worm, the ſmall gut is again diſtended, equal, ſmooth, and moderately large; but then a kind of ſmall tube, Tab. XLI. Fig. VI. *k*, is inſerted therein, which is divided into veſſels, either vaſa varicoſa, or rather the cæca, or cloſed guts. Theſe veſſels, like ſo many ſmall inteſtines, diſcharge themſelves into the beginning of the great guts, where the latter are united with this dilatation of the ſmall. Theſe blind or cloſed guts are of a wonderfully elegant conſtruction, and two of them are found commonly filled with a whitiſh humour; which in the more adult Nymph, I obſerve, is by degrees ſent alſo to the great guts.

This ſubſtance is ſometimes beautifully divided, as it were, into knots; and is likewiſe inwardly ſeparated, *mm*, by a more limpid ſubſtance, which ſeems mixed among it, like whey; that nothing can ſcarce be exhibited to the eye more artificially and beautifully diſpoſed, or more conſpicuous. The figure, I have given, exhibits only a ſmall part of this elegance, and that is but rudely drawn or delineated; becauſe, to expreſs it accurately, there would be need of a much larger figure. Theſe cloſed veſſels cannot, but with very great difficulty, be ſeparated from the fat that is annexed to them; and this difficulty is the greater, becauſe that white ſubſtance is not found in every part of them. Hence it is, that they are very eaſily broken. But this happens ſtill eaſier in the Worm, becauſe the blind veſſels are more ſtrongly connected in it; ſo that it requires more labour to diſcover them there. They diſperſe themſelves, *nn*, with various and wonderful windings and convolutions, through the whole belly; for they are ſeen no more in the thorax of the Nymph, which is all filled up there with the muſcles of the legs, and other parts. We at length obſerve, that the two ſuperior or uppermoſt of theſe inteſtines unite, *o*; and one of them is likewiſe divided twice on the inſide, and twiſted into admirable windings, *pp*: this goes towards the great gut, into which it diſcharges its contents. The other lower pair, wherein the above mentioned diviſion of the white ſubſtance is expreſſed, *mm*, are likewiſe twiſted into various windings, *qq*, and at length terminate *r* in the cloſed tube. The fourth of theſe inteſtines is circumſtanced in the ſame manner, *ss*; for after various convolutions, it terminates at laſt alſo in the blind annular duct, *t*.

The colon is alſo every where uneven, with many knotty dilatations, *u*. Theſe are produced by the white ſubſtance found in its cavity, whilſt the little inteſtine hath been contracting itſelf in thoſe parts, where it contains a leſs quantity of that ſubſtance. A little lower is ſeen a larger knot *x* in this inteſtine, filled with a black ſubſtance. And at length two more dilatations occur *yy* in it, which poſſeſs thoſe places of the inteſtine, which, by the help of the humours that flow into them, ſwell into very large bags. But as the little inſect, after putting on the form of a Fly, ſecretes and diſcharges that colluvies of humours; hence theſe windings may be properly called the cloaca, or ſewer. Laſtly, one may ſee the rectum, or ſtraight gut; and underneath, in the tail, the podex, or orifice through which the inteſtines diſcharge themſelves, *z*, in the laſt ring of the abdomen. I have alſo judged it proper to delineate this ring, as it coheres with the anus, in order to repreſent more clearly all the things which I have mentioned.

When the Nymph is older, I have ſometimes found its ſtomach filled with a green fluid: but when it approaches to the change of its ſkin, in order to acquire in a ſhort time the form of a Fly, its ſtomach and inteſtines are found ſo conſiderably contracted, and by degrees become ſo much ſhorter, that one would affirm one had diſſected another animal, unleſs one had obſerved all theſe changes, according as they gently ſucceed each other from the beginning.

In the lower region of the belly the cæcum and rectum, or blind and ſtraight guts, are expanded at that time very wide; and are found to be ſwollen, glittering, and ſmooth, on account of the white moiſtures or humours which are mixed with a chalky matter. Theſe humours,

mours, flowing out of the wounded cloaca, or liver, render every thing muddy; and, when thrown into the water, they likewiſe foul and deſtroy its clearneſs.

The double ovary *, which appears of a whitiſh aqueous colour in the young Nymph, is, in the more advanced ſtate, of a pale yellow colour. But if the Nymph is to change its ſkin immediately, it appears to be a beautiful green. In the region of the abdomen, where the ovary extends itſelf to the thorax, are ſeen two empty curled bags. They are the two pneumatic veſicles, as I ſhall ſhew more at large in the hiſtory of the parts of the perfect Fly. In the extremity of the body, between the laſt rings, appear three very beautiful tranſparent knots; each of which, being ſupported by its own footſtalk, caſts a ſkin, and diſcloſes itſelf, when wounded. What theſe little parts are, I cannot determine: I have diſcovered only, that they belong to the genital organs of the female; for I never ſaw them in the males, and therefore I ſhall delineate them in the figure of the latter.

The male part, at the ſame period of maturity, became by degrees conſpicuous; and, from a thin aqueous humour, having acquired ſufficient firmneſs, they had obtained a limpid and pellucid whiteneſs. The muſcles in the breaſt are at this time much more compact, and, from a pale white, become of a purpliſh colour. In the young Nymph they were ſoft, mucous, and like veal-jelly, and had no firmneſs.

But much more remarkable than theſe are thoſe changes, which, by a ſlow accretion of parts, are ſeen in the head, eyes, pulmonary tubes, and fat, which may be ſeen there in a very abundant quantity; and alſo in the horny little bones, which firſt conſiſted only of humours, as it were, and membranes. But I now paſs theſe things by, without further notice, becauſe I ſhall hereafter make mention of ſome of them in the Fly itſelf. Above the brain are ſituated two white, ſoft, little parts, ſomewhat like knots, which riſe like two horns: they are annexed to the ſides of the thorax, and reſt on the ſtomach, as on a baſis or foundation. But what theſe little parts are, as alſo their uſe, I am likewiſe hitherto ignorant.

I afterwards likewiſe obſerved in a Nymph, which I found dead in its ſkin, that the purple fat was there variegated with white ſpots. The little inteſtine, which I before deſcribed to be contained within one of the inteſtines, lay looſe therein, without adhering any where, and was curled; but that part of the inteſtine, which encloſed it, ſeemed to be very conſiderably dilated. The uvea of the eyes was of a very beautiful bright purple. Here and there, in the abdomen, were ſeveral ſmall Worms; ſome of which were already changed into Nymphs, and appeared to me as if they were to be transformed into Flies very ſoon. It would require a large treatiſe to deſcribe how ſuch things are produced in the bodies of other inſects, and what ſtrange and unheard-of things may be here further obſerved. So admirably does God ſhew himſelf before our eyes! and probably the relation would not be believed, if I deſcribed and delineated that a Nymph iſſues out of one ſpecies of Caterpillars, which belongs to the ſecond mode of the third order; and that out of this Nymph the Butterfly is afterwards produced; and that out of the ſame ſpecies comes a Worm alſo, which is again changed into a Nymph, according to the firſt mode of the third order, and at laſt aſſumes the form of a Fly. And further, that out of the ſame ſpecies of Caterpillars, ariſe two or three Worms, which are again changed into Nymphs of the fourth order, and theſe afterwards into ſo many Flies. Laſtly, that thirty, eighty, nay one hundred Worms have iſſued thereout, which have been likewiſe firſt changed into Nymphs, and afterwards into Flies. I have ſeen theſe twelve changes, which are very worthy of notice, diſtinctly in only one ſpecies of Caterpillars. And now, at length, I have learned that all theſe wonderful effects of Nature obtain likewiſe in water-inſects; but this I have not yet ſufficiently traced.

Though the changes of the inteſtines, a little before enumerated, are very ſingular in the Worm and Nymph of which I treat, thoſe which the ſpinal marrow undergoes deſerves yet the greateſt notice, and that preferably to the reſt. For as this marrow in the Worm was twiſted, as it were, into a curled lock; ſo, on the other hand, we find it extended very ſtraight in the Nymph, and almoſt all its eleven knots, Tab. XLI. Fig. VII. 1, 2, 3, &c. dragged or ſeparated from each other. This is chiefly ſeen about the laſt knots; but not about the foremoſt knots, or thoſe next to the brain, *a*; near or on the upper part of which I have delineated the cornea of the eyes. The firſt knot, *b*, preſerved its former ſituation; but the four ſubſequent knots, *c*, having ſuffered a quite different change, were preſſed cloſer to each other than before, and expanded to a conſiderable bump or ſwelling; and therefore the nerves, ſpringing from thence, were now conveyed in a very different manner. Nay, further, the origination of the ſpinal marrow is alſo ſeen, ſtretched and extended between the firſt and ſecond knot: and this, indeed, may be perceived ſtill more plainly about the ſixth, ſeventh, and eighth knot; and therefore only the three loweſt knots, *d*, remain in their former ſituation; though the laſt of them is likewiſe more conſpicuous than the two next above. If we would here follow Reaſon as our guide, ſhe would certainly have rather dictated, that the convolution of the marrow in the Nymph is extended in the

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* This double conſtruction of the ovary is almoſt univerſal in flying inſects, and it is the ſame in almoſt all the kinds of fiſhes; and the vaſt number of eggs bears likewiſe an analogy. In many fiſh the body of the female is filled with this ovary, as entirely as in inſects. The intent of Nature ſeems to be the providing, from the abundant eggs and young of ſome kinds, food for the others; for it never could be the intent, that all the eggs contained in theſe ovaries ſhould yield perfect inſects.

Worm, ſince the Worm is two thirds longer than the Nymph: and hence it ſhould ſeem neceſſary, that the marrow in the Nymph muſt be thus twiſted, by reaſon of the contraction of the body, which, as it were, accommodates itſelf thereto ſpontaneouſly. But experience teaches, that all our reaſonings here are of no conſequence.

Wherefore, if any one well conſiders theſe changes and extenſions of the nerves, and the knots of the ſpinal marrow, he will clearly ſee, that the change of the Worm into a Nymph, and of the Nymph into a Fly, the inſect, in the mean time, being one and the ſame, is, in reality, very miraculous, and may be called, as it were, a new creation, or rather generation; the true cauſes of which we are at as great a loſs to inveſtigate, as the nature of God, who is the author of this work. This ſhould certainly excite us to acknowledge the offenſive cloud of our own blind ignorance in every thing, and afterwards to ceaſe from pride and arrogance. It teaches us alſo, how largely the miracles of God are expreſſed in theſe ſmall creatures: they are, as it were, ſpontaneouſly evident to any one, with the leaſt pains, in the inveſtigation. However, one may obſerve, that ſuch changes are likewiſe obſerved in the larger animals; for the ſpinal marrow of the embryo, which, in the beginning, is hardly larger than a pea, is alſo inſenſibly expanded as it grows larger: yet one cannot, on the other hand, deny that this is only a ſimple augmentation of the parts, which produces ſuch changes in the larger animals. But in the inſects there is obſerved a remarkable tranſpoſition of the parts, and an admirable accretion of the viſcera; which, as it is performed in a ſmall ſpace of time, deſerves to be called miraculous, nor can it by any means be diſtinctly explained: for our eyes never diſcover, nor can they ever diſcover, how theſe things are really executed. Add to this, that the adult animal here grows young as it were again, and muſt receive other additions, until it is at length cloathed in a more noble body: all which tend to the honour and glory of God, the Supreme Deity, the Author of all theſe miracles.

CHAP. VI.

Of the true manner in which the Nymph breaks out of its outer and inner coats; ſo that, by a kind of viſible reſurrection, the creature afterwards aſſumes the form of a Fly. Alſo of the pulmonary tubes and inteſtines, the coats of which are drawn off, and left in the exuviæ.

WHEN the time approaches, in which the hidden inſect, now changed into a Nymph, in its outmoſt uncaſt coat, is to attain the form of a Fly, which change it performs in the ſpace of eleven days, the ſuperfluous humours, wherewith its members are ſwollen, are firſt inſenſibly expelled by perſpiration. The little body of the Nymph alſo, as hath been obſerved before, is contracted unto the fifth ring of the ſkin: and hence the four laſt rings of the abdomen and tail become empty and hollow, or are all filled with air, through the aperture of the reſpiratory orifice in the tail. The Nymph likewiſe yet draws its breath through the ſame aperture.

If you deſire to ſee this, expoſe the Nymph a little to the rays of the ſun, and afterwards put its tail into water. Thus you will find, that it will breathe ſtronger than it did before, and, by expreſſing an air-bubble out of its body, and again ſucking it in, will manifeſtly perform the action of inſpiration and exſpiration.

The anterior part of the Nymph's body likewiſe draws back from the ſkin, and having partly deſerted the beak, head, and firſt ring of the breaſt, the little inſect afterwards lies at reſt within its ſkin; until its exhaling members have acquired due ſtrength and firmneſs to break open thoſe two membranes, wherewith it is now ſurrounded, and hindered from coming into light. All theſe things muſt be here remembered, that what I ſhall ſay hereafter may be properly underſtood.

If, however, the outer ſkin be opened about this time, very wonderful varieties of colours, ſuch as one can ſcarce imagine, preſent themſelves through the inner ſkin, with which the Nymph is covered. Some of the parts are changed from white into black; others are of a yellow, purple, brown, or very black colour, like pitch; others, from aqueous, have become membraneous; and, from this latter ſtate, again become hard: ſome become fleſhy; others again acquire an horny or bony hardneſs, ſo that, when preſſed, they crack and break aſunder.

It is likewiſe obſerved at this time, that the whole body becomes inſenſibly ſhaggy, and the feet and claws begin to move. All theſe things may be diſtinctly ſeen, provided one opens one of thoſe Nymphs conſtantly every day, until the time of change. But, for this purpoſe, it is neceſſary to lay them on white paper in an earthen diſh, or glaſs ſaucer, and then to make them ſomewhat moiſt with water, and keep them under a glaſs. In this caſe, the paper ſerves the Nymphs to fix their claws in, when they come forth under the form of a Fly; and I pour in a little water, to preſerve them from drying and ſuffocation.

When the creature is at length to come in ſight, the outmoſt ſkin of the Worm begins to move about the third and fourth anterior ring, Tab. XLII. Fig. I. *a*. This motion ariſes from hence, that the inſect, now hidden within the ſkin, uſes all its efforts to promote its excluſion, and to quit its inmoſt coat as well as its exterior ſkin together, at one and the ſame time. This is conſtantly the courſe of nature, in our fourth order of changes. It is obſerved, on this occaſion, that the ſkin is divided into four parts: hence it happens, that the third *b* of the foremoſt rings, and alſo the fifth, *c*, are partly ſeparated; and even theſe, as well as the fourth above, open very regularly and orderly in the breaſt. After this, the inſect immediately breaks open its inner coat, with which it is immediately inveſted, and caſts it off, together with the ſkin, breaking forth from thence under the beautiful form of a Fly, Fig. II. *a*.

But I would have it here obſerved, that the breaking open of the outmoſt ſkin, as now explained, is not at all caſual or accidental; but is perfectly ordained by a conſtant order, ſince it always proceeds in the ſame manner in all theſe changes. The ſkin alſo is in thoſe places, where it is broke open, ſo circumſtanced by the all-wiſe Author of Nature, that it eaſily opens, as if joined together by ſutures.

When the Fly is thus produced, its wings are not immediately obvious, or diſtinctly viſible; but are curled up, and wrinkled into folds, in the ſame manner as I have exhibited in the Nymph. However, in the ſpace of a quarter of an hour, which is well worth obſerving, we ſee that they are diſplayed and extended, and become ſmooth. The cauſes of this ſudden effect are the blood and air, which are then impelled forcibly into the veſſels of the wings and pulmonary tubes: therefore, if the wings about this time be wounded, they ſhed ſome ſmall drops of the creature's blood, like clear flowing water; and this never happens afterwards, when the wings are once expanded and dried, though you wound them never ſo often.

When the wings are expanded, the little inſect diſcharges three or four ſmall drops of muddy water, and immediately enters into another ſtate of life: for the creature, that lived before in water and mud, now wanders thro' the air, carried by very ſwift wings, and viſiting the graſſy fields and meadows, enjoys a more noble and happy kind of life.

In the ſame quarter of an hour, wherein this creature is produced, it hath alſo acquired the knowledge of every thing neceſſary to do what it ought, and to avoid what may prejudice it; wherefore it never afterwards has occaſion of a tutor, or director for any thing. Hence the birth of this inſect by far excels the unfortunate condition of man, after he is born. He for ſome years increaſes or grows up, as it were, in diſagreeable circumſtances, before he has reaſon, or a knowledge of thoſe things which he ought to do, or avoid: but, on the contrary, this inſect is of full maturity when born; nor does it increaſe any more after the quarter of an hour, in which its birth is compleated; but it feeds itſelf with a moſt diſtinguiſhed kind of pleaſure, and lives on dew and ſugared liquors, which it finds in the meadows and flowers: indeed, it ſometimes nouriſhes itſelf with blood, to the juſt puniſhment of the ſins of Man, who is more miſerable than the Worm fixed to the earth, and thrown into this world as into exile. This Fly naturally torments cows and cattle, that ſerve for the uſe of man, in ſuch a manner, that they run through the fields mad, as it were, with pain.

Relying with juſt reaſon on theſe things, I can at length affirm, that the aforeſaid metamorphoſis of the Worm into a Nymph, under which change the Nymph is for ſome time, as it were, dead, and deſtitute of motion, and, after the ſhort ſpace of eleven days, increaſes into a Fly, by the wonderful alterations of the internal parts; may be juſtly compared to the true reſurrection from the dead, or, as it were, to a new generation. The human underſtanding is, indeed, amazed at this; but at the ſame time we are taught thereby, as with a viſible example, how near our reſurrection and reformation is, when we love God above all things, and our neighbour as ourſelves; in which conſiſts, indeed, the real metamorphoſis of the human mind. This, having then caſt off the ancient dirt of avarice, pride, and envy, and changing thoſe vile paſſions for the moſt ſweet and gentle love of Chriſt, lives afterwards eternally in a more perfect body.

The Fly, thus produced from the Nymph, exhibits two antennæ, or horns, Tab. XLII. Fig. II. *a*, on the head. The four anterior legs are jointed to the lower part of the thorax. The two laſt are ſeen *bbbb* under the poſterior part of the body, and ſhew very diſtinctly their joints, and the two claws, with which their extremities are fortified. Two little apapertures are ſeen in the upper part of the thorax; but its poſterior region is girded round with a beautiful margin, near which, on each ſide, are ſeen two little parts, with globular extremities, deſigned for making a noiſe or ſound. The two wings are affixed *cc* to the ſhoulder-blades. The body, *d*, is divided by ſome yellow ſpots, with black horny or bony rings, which are beautifully adorned above and about the ſides with fine hairs. I had once intended to delineate theſe things magnified; but I am now ſo ſtinted in time, that I cannot execute this deſign.

The other miracles of God, ſhewn in this inſect, muſt be now exhibited to view; I mean, thoſe which occur in the ſkin, and in the inner integuments, which have been forſaken by this Fly. I ſhall now ſhew theſe exuviæ, or caſt parts, diſſected and magnified by a microſcope. In the hinder part of the outer ſkin, the caſt off pulmonary tubes, *a a*, which, upon the Worm's being changed into a Nymph, and contracting its body into the fourth annular inciſion, had ſeparated from its interior parts, ſtill adhere to the ſecond, third, and fourth rings: and as the body was wrinkled at that time, it happened that theſe pulmonary tubes were turned out of it, through the poſterior apertures of the tail, and remained fixed to the reſpiratory points or breathing-holes of the outer ſkin. From conſidering therefore this poſition of the exuviæ, it is eaſy to underſtand how the inſect has at that time, beſides other changes, ſuffered ſo great a contraction of its body. The extended extremities, or ends of theſe pulmonary pipes, being protended forwards, are curled and twiſted, *b b*; which proceeds from hence, that when the Worm contracts its body upwards, from the tail to the thorax, theſe pulmonary tubes are, by their own inſertions, and this force, thrown out of the body: and hence it happens, that theſe being afterwards left to themſelves, they fly back, as it were, and from ſtraight run into curled ſtrings or cords. This I once plainly ſaw, when I opened the ſkin about that time.

The like operation has place alſo, with reſpect to the inner *c* coat of the inteſtines; which then likewiſe ſeparates from the body, and remains fixed to the ſkin, very beautifully repreſenting the complicated web of a Spider. Within, in this little inteſtine, which is of a beautiful white colour, are found ſome particles, like grains of ſand, clear as alum, and conſiſting of many points and diviſions. I firſt thought theſe were ſand; but I afterwards ſaw that when they were mixed with ſpirit of vitriol, they fermented very ſtrongly, which is not a property of ſand. And, therefore, as I am unable to explain the nature of many other parts, ſo I do not know what this ſubſtance is; whether it be of any uſe in the body, or whether it probably contains the calcarious, chalky, and alcaline particles of excrements? I therefore, here again, candidly confeſs my own great ignorance. If we invert this part of the inteſtines, and the tail, we may likewiſe ſee how the ſeparating inteſtine, Tab. XLII. Fig. IV. *a*, inwardly detaches itſelf from the inner cavity of the ſtraight gut or rectum, *b*; and, when ſeparated, remains fixed to the external orifice of the fundament, which opens *c* within the outer ſkin. This I have roughly delineated, the better to explain it.

In the anterior or fore-part of the Worm's exuviæ, are ſeen the legs, beak, eyes, Fig. III. *d*, and ſkull, *e*, left and caſt off together *. There is likewiſe ſeen the coat, which parted *f* from the internal ſurface of the gullet and ſtomach. But it is neceſſary to take notice here, that every thing, hitherto mentioned, happens when the creature firſt aſſumes the form of a Nymph.

When it afterwards, upon breaking forth under the form of a Fly, quits this outmoſt ſkin and the inward pellicle together, there are again other remarkable things obſerved, which I ſhall now deſcribe. In the firſt place, I exhibit, as now caſt off, *gg*, the hitherto hidden inward coat, which had inveſted all the Nymph's limbs and parts, and which is now irregularly broke open in the fore-part, together with its outmoſt ſkin. This may, indeed, be eaſily done, on account of its thinneſs. In its hinder part, one may ſee where the tail, *h*, or the extremity of the Fly's body, was before ſituated within it. In each ſide of this ſkin are ſeen the pulmonary tubes, rolled out, and all terminating *i i* in a pointed extremity, like ſo many ſmall tops or points of needles, tho' each of them may be very eaſily ſeparated into many branches.

But it muſt be here again obſerved, that theſe pulmonary tubes do not ſeparate or go off, when the Worm is changed into a Nymph: for, otherwiſe, the Worm muſt have crept out of its external ſkin; as, indeed, is always the caſe in ſome other orders of tranſmutations. But ſince that does not hold here, therefore the moſt wiſe Creator has ordained that theſe changes ſhall happen, when the Worm, on forſaking both its ſkins together at the ſame time, and being cloathed in more noble ornaments, and under this form afterwards dignified with the name of a Fly, is to come to light. Theſe things, indeed, afford us matter very worthy of conſideration. We are excited to induſtry not only by the ſmall Ant, but may draw knowledge and learning from the contemptible Fly. And thus all things tend, at length, to the honour and love of the Supreme Architect, whoſe works are evidently the open books of Nature.

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* It is univerſal among inſects, that the creature which has put off its exuviæ, or caſt its ſkin, immediately appears much larger than it was before. This is indeed true in fact, as well as in appearance. The body has by degrees grown under the ſkin, till it is too large for it; and this is the very reaſon of the throwing it off. As the increaſe has been gradual, and the parts are ſoft, the ſkin has preſſed them together, and they lie cloſe; but as ſoon as this ſkin is caſt off, they diſtend themſelves, ſo as to appear in their proper form.

CHAP. VII.

Treating very particularly of the Aſilus, or Gadfly, and its external and internal parts, as well male as female.

NOW that we have ſeen the order in which the Worm grows or increaſes into a Nymph, and how this latter is at length changed into a Fly, and conſequently appears under three different forms, though it always remains one and the ſame inſect; it is neceſſary, for my purpoſe, to exhibit particularly the parts of the Fly. This I ſhall now attempt to do, and I ſhall begin with the male; and afterwards deſcribe thoſe parts in the female, which cannot be ſeen in that ſex.

The male Gadfly, conſidered externally, ſhews itſelf divided into the head, the thorax or breaſt, and the abdomen or body. Theſe three parts are joined together, as it were, by a ſmall filament; and this makes a moſt beautiful figure in Waſps. This is the reaſon why theſe creatures are called inſects.

In the head the eyes, horns, and proboſcis or trunk, are very conſpicuous. The eyes are ſmooth, of a dark browniſh-green colour; and they ſeem ſpotted, upon a tranſparent gold-coloured ground. Their ſtructure is like that of the Bee's eyes; for each conſiſts of a collection of many leſſer eyes, between the hexagonal diviſions of which ſome hairs are ſcattered up and down. A ſmall, black, horny margin divides theſe eyes one from the other. The hinder part of this margin, which lies upwards towards the thorax, is likewiſe adorned with three larger eyes; the two hindmoſt of which are ſomewhat ſmaller, and the two fore ones as large again. In the neck, or where the beginning of the medullary ſubſtance is joined to the cerebellum in us, there are obſerved two yellow ſpots.

In the foremoſt region of the head, where the margin juſt mentioned reaches towards the mouth, two very beautiful horns, of an obſcure blackiſh colour, are placed in the middle. Theſe are divided each into eight joints, whereof the lower are longeſt, and are ſet with fine hairs. About the mouth are likewiſe ſeen a conſiderable number of hairs, of a glittering deep gold colour. The mouth has no opening, as in other inſects; for the proboſcis or trunk, like an hollow little tongue, is here placed in the mouth; and through it, as through an hollow tube, the Fly, when eating, conveys its food into the ſtomach.

By preſſing the thorax with the fingers, this proboſcis will come in ſight out of the mouth: in its fore part appear two oval bubbles, Tab. XLII. Fig. v. *a*; the middle parts of which are applied to each other lengthwiſe, and between theſe the food paſſes to the ſtomach. Their upper part is beautifully divided with various pulmonary tubes, which, like ſo many ſemi-circles, run from one ſide to the other. The proboſcis alſo has briſtly hairs *b b* on each ſide of it, which, ariſing out of the outer ſkin of the mouth or lips, hide the trunk itſelf, when drawn back by the Fly. The inferior or lower part of the proboſcis has two ſmall *c c* appendages; out of the ends of which, conſiſting of a black horny bone, likewiſe ariſe ſome hairs. They are jointed into a ſingular kind of black *d* horny triangular bone, which gives conſiderable ſtrength to the membranous parts of the tube, which ſupports the proboſcis. Beneath this is afterwards ſeen another horny bone, which is of a different figure, *e*. I have not yet been able to diſcover the aculeus or ſting in this Fly, though it ſhews itſelf very viſibly in the Horſefly, which carries it encloſed in a ſmall ſheath. Whether the great tenderneſs and fineneſs of the ſting prevented my finding it, or whether I miſſed diſcovering it, I cannot ſay. Neither can I explain in what manner this little inſect ſucks the blood, ſince I have never learned this from obſervation. I have ſaid, indeed, in my general hiſtory of inſects, that theſe little creatures had a ſting or point in their mouth; which, I believe, to this time is the general conſtruction, tho' I cannot at preſent demonſtrate it.

The ſhape of the thorax on the upper ſide, or in the back, is oblong, and it is moderately hard like a horny bone. It is in ſome of theſe Flies, covered very thick with fine hairs. Its upper part is bent a little inwardly at each ſide: and hence it happens, that two holes, as it were, are there formed; beſides, each ſide of it is ſet with thin hairs. In the loweſt region of the thorax are ſeen ſix legs; they are articulated to the thorax. Each of theſe legs conſiſts of five joints; the laſt of which is again ſubdivided into five ſingle joints, and is armed with two rediſh claws, having their extremities as black as pitch. All theſe joints have alſo briſtly hairs, and are conſtructed or formed of a horny or bony matter, ſomewhat hard like lobſter-ſhells: within this the muſcles, veſſels and nerves are placed. On the upper and hinder part of the thorax are two wings, of an even and generally ſmooth ſurface; though they have ſome few hairs diſperſed over them. A conſiderable number of pulmonary pipes is alſo diſtributed through theſe wings, and theſe divide them as ſo many ſmall nerves. The membranous parts of the wings are ſomewhat wrinkled, or plaited with ſmall folds, and they are of a colour approaching to a pale red. The wings are, by the help of their joints, connected with the back; where the muſcles, which move them, are inſerted therein. Four ſmall folds of the wings are likewiſe ſeen there; whereof the lower are beautifully ſurrounded with hairs; and where the contracted wing reſts, they are received by a kind of hole or pit, conſpicuous in each ſide of the thorax;

and this likewiſe has ſome ſetaceous hairs, but not placed ſo regularly. Near theſe appear two globules, each of which is ſupported by a bent or crooked ſmall foot or peduncle, and theſe reſemble the iron head of a hammer. All the little parts, juſt now enumerated, ſerve for modulating the air; for, as this is driven out of the thorax into theſe cavities, hence is produced that craſhing noiſe in the ſides of the body, made by the Fly when it diſplays its wings in flying. The malleoli, or little hammers, in particular, are very beautiful, and ſuch are found almoſt in all Flies: but I never ſaw them in any ſpecies of Bees; that is, the Bees have four wings: and therefore they produce their ſound or noiſe in a quite different manner. The ſame may be alſo obſerved in Locuſts and Graſhoppers. Indeed every kind of inſect has particular inſtruments to vibrate and modulate the air. The part of the back oppoſite to the abdomen, is adorned with a yellow margin; out of which ariſe two ſharp-pointed little parts, like ſharp needles, terminated by black points. However, you may more eaſily diſcover theſe little parts by the touch than by the ſight, becauſe they are ſurrounded with a great number of hairs.

The abdomen, in like manner, conſiſts of a horny or bony ſubſtance, and being ſet all round with hairs, has five yellow ſpots on each ſide, which are here and there as if folded up, and laid ſmooth, and without hairs. It is moreover divided into ſeveral rings, which are diſpoſed in the ſame manner in the male as in the female: though, in reſpect to the particular ſtructure, there is ſome difference between them, as far as they conſtitute the Fly's tail; but this difference cannot be ſeen, unleſs when theſe parts are preſſed backwards.

As to the external parts, there is no difference between the male and female, except with regard to the bigneſs of the body: the male is a full third part leſs than the female, which is likewiſe the caſe in the Worm alſo, and the Nymph; for thoſe which are to produce males, are leſs than thoſe which are to yield females. The female muſt carry in it an ovary, which, as it contains ſo great a number of eggs, that it cannot be comprehended in a narrower compaſs, it is therefore neceſſary that ſhe ſhould have a larger body. To make this the more evident, I ſhall now deſcribe the inward parts of the Fly, and their difference in the male and female. Let it be here obſerved, that it is a female I have delineated here, and deſcribed in general.

Before I proceed to the internal parts, I muſt obſerve, that all the Flies which belong to this ſpecies, do not exactly agree with one another, in regard to their ſpots, colours and hairs, which is alſo the caſe in their Worms; between which there is great difference in regard to their paler or fuller colour.

Now, if, in order to ſettle the diſſection of theſe Flies, you deſire to kill them in ſuch a manner as not to hurt any of the parts, there is nothing ſo proper for this purpoſe as ſpirit of wine, in which they die immediately: however, I could not entirely kill the Worm in this liquor. I have killed a young Fly in the ſpace of three hours, by the ſmell of Braſil tobacco, put near it in a flask: and this indeed I have often done ſince.

In the head of a male Fly of this ſpecies, two days old, I obſerved that little particles of fat became conſiderably ſmaller than I before deſcribed them in the Nymph. When I had afterwards removed the cornea from the eyes, the colour of the uvea, which ſtill lay within that, appeared of a bright red. I obſerve alſo, that the colour of the uvea is very different in proportion to the age of the Flies: for thoſe that have very recently caſt their skin, ſometimes ſhew the uvea of a very beautiful and full orange colour.

All the muſcles of the legs and wings, which are inſerted in the horny or bony inveſting coats of theſe parts, were in this Fly entirely perfect. I found little fat here. But the belly, when opened, appeared to be very full of it. This fat was of a purple colour, and its particles globular; ſo that at firſt ſight I took them for eggs. Theſe fat particles very eaſily ſeparate at this time from the pulmonary pipes. Theſe tubes were become much leſs, and more contracted, on account of the great loſs of the conſiderable coats which they had caſt off; but I could not find any tube among them dilated into veſicles, as is the caſe in many other inſects. I further obſerved alſo, that the largeſt branches of the pulmonary tubes, which I have before deſcribed in the Worm, were here in the Fly compreſſed, and inſenſibly worn away, as it were, or aboliſhed: and the ſame thing is true with reſpect to the bags, out of which the Silkworms ſpun their ſilken threads.

I obſerved alſo two conſiderable pneumatic bladders of a pear-like ſhape; one of which I here delineate, Tab. XLVII. Fig. VI. *a*. They were large, and very much dilated, and were ſomewhat curled in the curvature of their tops, in the manner of thoſe little purſes, in which the earth Spiders carry their eggs about them: this happens probably, becauſe theſe bladders have not been extended as much as they might. Each of theſe was terminated by a cloſer tube, *b*, compoſed of orbicular rings; out of the ſides of this other ſmall branches, *c c*, iſſued here and there; two of which I here exhibit magnified. Theſe pulmonary tubes are principally conveyed towards the ſides of the body, under the wings, and there forming ſmall orifices, they afford the air by which the Fly makes or produces its noiſe.

The ſtomach and inteſtines were in this Fly very much contracted. I found a little air in the ſtomach, and in its hinder part near the pylorus, a browniſh yellow fluid. The little inteſtine found in the other inteſtine, was wanting in this ſubject, having been waſted away. The four convolutions of the four cloſed or blind inteſtines, were here found forced out of the breaſt into the belly. The rectum ſhewed itſelf dilated to a conſiderable width, and filled with a white moiſt ſubſtance like chalk.

Below, in the abdomen, were ſeen the genital parts; the penis, the teſticles, and the ſeminal bladders. The penis is ſituated underneath, within the laſt ring of the abdomen, thro' which is it erects and ſtretches itſelf. Its forepart is divided into three horny or bony points, Tab. XLVII. Fig. VII. *a*, variegated with a paliſh yellow colour, ſomewhat approaching to red: the middle one of theſe is properly the penis, which can erect itſelf internally, and puſh through the horny little bone, wherewith its hinder parts are inveſted. It is connected as by two joints, *b b*, with black horny little bones, twiſted into ſerpentine windings, which I here repreſent, joined to the hinder part of its horny ſheath. Moreover, this can bend itſelf in ſome degree about the middle, *c*; its caſe, or ſheath, being there a little more membranous: hence the penis ſeems to exhibit a joint in that part. The laſt or extreme ring of the belly, wherewith the penis is articulated, is likewiſe adorned with two margins or verges, which are ſmall, horny, or bony, black, and conſiderably ſtrong, *d d*; and in the forepart, are, as it were, jointed with the horny little bones, which are bent in a ſerpentine manner *e e*. I have here delineated that ring open: for all theſe horny little bones are cloſely joined together, and cover, as it were, the penis.

The ſoft and nervous part of the penis, twiſted in a ſerpentine *f* manner, runs inwardly into the cavity of the abdomen, and is there at length dilated into a conſiderable knot, *g*; into which the teſticles, *h h*, and ſeminal veſicles, *i i*, diſcharge their ſperm through four orifices, and thus convey it to the penis. The teſticles, when diſſected, ſhew themſelves to be compoſed of very numerous, ſmall, very ſhort and tender *k k* tubes, with their ends cloſed; all which threw their ſperm into the vas diferens, *l*, by which it is conveyed on further. The ſeminal veſicles are not ſo conſiderable; but they deſerve notice, on account of ſome bendings and curlings, *m m*; they terminate in delated extremities. Their ſperm, as well as that of the teſticles, is white; though the teſticles are not ſo white as the ſeminal veſicles.

The ſpinal marrow is here diſpoſed in the ſame manner as it is in the Nymph.

I find the ſame parts in the female as in the male; only that an ovary is found in that ſex, inſtead of the male genital organs. This ovary is divided into two parts, Tab. XLII. Fig. VIII. *a a*, and being *b* faſtened to the laſt rings of the abdomen, it opens there by a large orifice, and diſcharges its eggs; theſe the Fly always drops into the water: this is likewiſe the practice of the Perla or Dragon-fly. Theſe hinder rings of the body, are here and there very beautifully variegated with black, horny, or bony ſpots of different figures, *c c c*, and are likewiſe beautifully adorned all round with hairs *d*.

The eggs in the ovary ſeem to be exactly ſpherical, and to exhibit each an opening in the middle of it, *e e e*: but this is only a falſe appearance, produced from their too obſcure colour. In reality theſe eggs, are oblong; and they become the longer and more acute, *f*, as alſo larger and more conſpicuous, the longer time has paſſed ſince the Fly's change; ſo that they inſenſibly fill the body more and more. But if theſe eggs be laid before a microſcope, that magnifies in a great degree; then their real figure is diſcovered, together with the pulmonary tubes, *g*, which connect them every where, and which furniſhing many ſhoots, *h*, diffuſe *i i* themſelves through the whole ovary in ſeveral beautiful branches. No veins or arteries are ſeen here; becauſe theſe little creatures have white blood, as alſo on account of their great ſmallneſs.

In the young Fly theſe eggs are very tender, and of a beautiful colour; which becomes the ſtronger or fuller, in proportion to its age. In one ovary of this kind, I have diſtinctly counted about four hundred and forty eggs: hence it is evident, what a great number of Worms one Fly may produce.

I have placed water, ſweetened with ſugar, before ſome of theſe Worms; but they did not touch it, and died the fourth day. Others lived much longer, and the more ſo, the more they were expoſed to the cold and rain; for then almoſt all inſects abſtain from eating. I have neglected to offer them blood.

In one of theſe Flies, which I opened alive, all the fat was conſumed, ſo that no part of it remained, but thoſe purple little membranes, with which I had obſerved it before ſurrounded.

Laſtly, near the orifice of the ovary, which diſcharges, Tab. XLII. Fig. VIII. *k*, itſelf, thro' two ducts, I have diſcovered thoſe three very beautiful little knots, whereof I have before made mention in the Nymph. The extremities of thoſe Nymphs are twiſted, *l*, or turned like a ſnail-ſhell: and they are then inflected or bent, *m*, in a ſingular manner, then curled, *n*, and run towards the laſt ring of the belly, and are placed *o* near the ovary. Where theſe knots form *m* their bending, ſomething like a common membrane joins them together. But if they be diſſected, there are as many pulmonary tubes ſeen encloſed therein, as they are in number. The coat or membrane, which inveſts theſe pulmonary tubes, entirely dries away and periſhes, if theſe are put on a glaſs, and leaves the tubes bare with open cavities. By opening the ſaid knots alſo, one may turn the air-tubes out of them unhurt.

The uſe of theſe little parts is utterly unknown to me; I cannot even conjecture for what purpoſe they are formed. There are alſo many other parts of this inſect, concerning which I am as much at a loſs. Wherefore, all who read theſe matters, as well as myſelf, being convinced of our ignorance therein, are obliged ſubmit to before God; who hath ſhewn himſelf ſo incomprehenſible and adorable in this inſect. We are obliged to extol him with praiſes, for that he hath been graciouſly pleaſed to diſcover to us ſo many, and ſuch great things in this creature. If we cultivate and exerciſe together theſe two duties under ſuch reſearches, the viſible things will ſerve to excite and encourage us to know and ſee God, from thoſe objects which he created, and to love him cordially, and like children, as the ſupreme venerable Deity.

The End of the Hiſtory of the Gadfly.

*A Letter written by the author to Mr. Thevenot, on the nature and anatomy of the Worm bred in rotten cheeſe, or the Acarus, and called by us the Mite, and of the Fly produced from it.**

SIR,

I Doubt not, but at the time when you held weekly conferences at your houſe in Paris, and thereby made it a general place of meeting for the learned, ſome of your inquiries turned on the nature of Mites, their ſingular diſpoſition, and ſurpriſing manner of their ſpringing up into the air. I therefore take the liberty of ſubmitting this little treatiſe to your judgment, which I reſpect and value infinitely more, than the opinions of many of the profeſſed litterati of the preſent age, whoſe inquiries into natural things, ſeldom go deeper than the ſurface.

I am not ignorant, that the illuſtrious Redi has wrote with great knowledge and accuracy concerning Worms, which are bred in cheeſe; but I know alſo, that he could not poſſibly be thoroughly acquainted with all the circumſtances remarkable in thoſe inſects; and that the great number of uncommon experiments which he propoſes, could not but hinder him from applying himſelf thoroughly to all parts of the ſubject, eſpecially as he, at the ſame time, paid his attendance at the court of the great duke of Tuſcany.

I have therefore taken upon me to lay before you, moſt illuſtrious philoſopher, a full account of this little Worm, and its Fly, their external appearance, their diſpoſitions, and their internal ſtructure; for I can take upon me to affirm, that the limbs, and other parts of this Worm are ſo uncommon and elegant, and contrived with ſo much art and deſign, that it is impoſſible not to acknowledge them the work of infinite power and wiſdom, to which nothing is hid, nothing impoſſible. You will ſee theſe minute creatures have, as well as the greateſt, a brain, nerves, muſcles, lungs, ſalival ducts, a ſtomach, ſmall and large inteſtines, cæca, or blind guts, pinguiferous or fat membranes, and the ſeveral other viſcera.

The external parts of the Mite.

ALthough this Worm is very common, I have thought it not amiſs to give a figure of it at its full growth, and of its natural ſize, Tab. XLIII. Fig. I. as names are equivocal, and there are many who know but little of it. Theſe ſmall creatures being generally held in deteſtation, though ſome eat them voluptuouſly with the reſt of the cheeſe, from a vulgar notion, that they are formed out of the beſt parts of it; whereas in reality, they proceed ſolely from the eggs of a common Fly, as I ſhall preſently demonſtrate. But before I undertake to explain the diſpoſition of this Worm, and give ſome account of its internal parts, as they appear on diſſection; I ſhall deſcribe its external parts, as well as ſuch internal ones, as the tranſparency of the outer ones affords us an opportunity of examining, without being obliged to diſſect, it.

The Mite, when viewed with the microſcope, appears divided into twelve ſections or rings, Fig. II. 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12. The firſt of theſe rings, properly ſpeaking, forms the head *a*, the ſkin of which, as likewiſe that of every other part, is tough and firm like a piece of parchment; ſo that it is no eaſy matter to break or wound it, though the Worm leaps with a ſurpriſing violence, on being ever ſo gently touched. The forepart of the head is, in a manner, divided or ſeparated into two tubercules, from which ariſe two very ſhort antennæ, or horns. Between theſe two diviſions of the head, there conſtantly appears, through the tranſparent ſkin that covers it, a ſmall particle, which, like the head, conſiſts alſo of two diviſions. This little particle really contains the organs conſtituting the mouth, which are of a ſubſtance between bone and horn, and produce on their forepart two little black claws, which ſerve the Worm not only as ſuch, but likewiſe for feet, and in the place of teeth. We may alſo clearly perceive thro' the inſect's tranſparent skin, that it can move theſe claws in and out, together with the already-mentioned parts of the mouth, in the ſame manner as the Snail thruſts out, or draws in, its head and horns.

The next ring is very remarkable on this account, that the pulmonary tubes of the inſect ſcarcely open any where elſe, except in the hindermoſt ring of the body, where there are two more: I could never diſcover any other breathing-holes, or apertures, in this inſect. Thoſe in the front ring next to the head, are very large. Theſe extremities, or rather the beginnings of the lungs, Tab. XLIII. Fig. II. *b*. are curiouſly contrived, and elegantly conſtructed. On the forepart, where they are thruſt out beyond the skin, they are of a membranaceous ſubſtance, ſomewhat white, and very delicate; a little lower they ſwell, as it were, into a ſmall belly, and grow yellowiſh, and in ſome meaſure to appear of a golden brightneſs. After this, they grow narrower towards the third ring, where we may plainly perceive, through the inſect's clear skin, that after acquiring a ſilver whiteneſs, like mother of pearl, they unite with the branches of the trachea, ſerving as larynxes. One great advantage the inſect draws from theſe openings, being placed forewards, near the beginning of the third ring, is, that when it draws in its head and legs, as it burrows in the moiſt cheeſe, theſe larynxes are covered by the folding of the skin. A contrivance worthy of its great Author, the ſole fountain of every thing good and wonderful. Within the third ring there plainly appears, through the tranſparent skin, the two great branches of the wind-pipe, which communicate about the beginning of the fourth ring, by a very conſpicuous anaſtomoſis or inoſculation. There are alſo many other ſmaller branches of the trachea iſſuing from the two great branches, which are placed within the third ring; and theſe ſmall branches aſcend towards the ſecond ring, and toward the head. I have omitted theſe ramifications in the drawing, for fear of rendering it confuſed. There appear beſides, tho' ſomewhat obſcurely, ſome other internal parts, through theſe rings. In the fourth ring there are ſeen two more branches of the trachea, iſſuing on each ſide of the breaſt from the two main trunks *cc*. Of the two ſmall branches laſt mentioned, one goes to the fourth, and the other to the fifth ring, where they join the branches ſpringing from the trachea in this place by a double inoſculation, or anaſtomoſis, that is eaſily diſcernible.

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* It has been a cuſtom to call any ſmall creature found in cheeſe, in Latin, Acarus, and in Engliſh, Mite. This author takes the the accuſtomed liberty of ſpeech, and gives, in the preſent account, the name Mite to the Maggot of a ſmall Fly; but the creature we commonly call Mite in England, and which is moſt univerſally called Acarus in Latin, is of a different kind; it is made ſmaller than this Maggot, and appears like a moving particle of duſt. This is the Acaris of the antients, which Ariſtotle obſerved in decayed Bees-wax, and was called the leaſt object of the human ſight. This Mite has ſix legs, an oval or rounded body, with a hard ſkin, and very diſtinguiſhable eyes. The Maggot here treated of under the ſame name, is a creature altogether diſtinct.

I do not find, that the greater branches of the wind-pipe form a mutual inoſculation, or anaſtomoſis with each other, any where, except about the beginning of the fourth ring; but the ſmaller branches ariſing from the ſides of the greater, and which appear very diſtinctly on each ſide of the body extended all over the annular diviſions, communicate with each other in a very obvious and conſpicuous manner. This may be beſt ſeen on the declivity of the breaſt and belly, above the borders viſible in thoſe places, as alſo in the rings of the left ſide, marked in the figure with the numbers 5, 6, 7, 8, 9, 10, 11, 12, and the letters, Tab. XLIII. Fig. 11. *ddd*, &c. There appear, beſides many other, ſmaller branches in the ſame places, which ſpring from the greater, and extend to the viſcera within.

All the other rings, from the fifth to the eleventh, are conſtructed alike; and the ramifications of the pulmonary tubes, which ſhew themſelves thro' theſe rings, are nearly of the ſame form: the principal difference, and that too is only accidental, as it is called, is, that the other internal parts of the Worm ſhew themſelves a great deal more plainly thro' ſome of the rings, than they do thro' others. In the fifth ring ſome particles of fat may be diſcerned thro' the skin *e*, and ſome more, tho' very faintly, in the ſixth. In the ſeventh and eighth, I could perceive ſome of the cæca, or blind guts, or cloſed inteſtines *ff*. Theſe, on account of their contents, appear of a very pale colour, in ſome degree approaching to green; the ſame alſo I could ſometimes perceive, pretty diſtinctly, thro' the ninth ring, tho' at other times very little or not at all. In the tenth ring, and between the principal trunks or branches of the wind-pipe, which extend themſelves along the back of the Worm from one end of its body to another, there generally appears a conſiderable branch of the trachea *g*, running to the internal parts. In the eleventh ring, there is ſeen a very remarkable particle of fat *h*, reſting upon two branches of the wind-pipe; but it has been only in ſome Worms that I could perceive this: it is not univerſal.

The twelfth ring differs in conſtruction from all the others; for the two greater branches of the trachea terminate there, projecting at their extremities in the ſame manner as the leſſer branches of the trachea do beyond the ſurface of the body. The projecting parts are, like the other breathing holes near the head: they are of a pale colour, but formed in a different manner, as may be ſeen by looking over the figure.

To conclude: the ſurface of this twelfth ring, is covered with a variety of prominent tubercles, and little cavities like wrinkles; the uſe of which I ſhall hereafter deſcribe.

Of the diſpoſition of the Mite.

THUS, Sir, I have deſcribed, in a few words, the external parts of this Worm, and ſuch of the internal ones as appear thro' its tranſparent skin. But all theſe particulars will appear of little conſequence, when compared with the wonderful contrivance that is ſeen in every part, when more minutely examined: ſuch a contrivance, as the great Architect of nature alone can thoroughly underſtand, or could form; the moſt ingenious inventions of man being, in compariſon with it, lame and defective.

The figure I here give of this Worm, which is ſurpriſingly ſtrong, and has a moſt vigorous conſtitution, repreſents it lying on its back, and ſeizing its tail with its teeth or claws; but this poſture is not, as you may gueſs, the natural condition of this Worm, nor is it ever found lying on its back, when alive; ſo that my only deſign in giving it thus, is to be better able to explain the manner of its leaping, in the moſt ſatisfactory terms. By turning the figure, you will have a moſt exact and natural repreſentation of the little inſect, preparing to make a ſpring.

When this creature intends to take a leap, it firſt erects itſelf upon its anus; in doing which, it is greatly aſſiſted by the prominent tubercles

tubercles of the twelfth ring, which enable it to maintain an equilibrium, by projecting more or leſs at its pleaſure, from the body. Immediately after this, the creature bends itſelf into a circle, and having brought its head, Tab. XLIII. Fig. III. towards its tail, it preſently ſtretches out its two black crooked claws, and directs them to the cavities formed between the two laſt or hindmoſt tubercles of the body, where it fixes them in the ſkin; as the ſecond figure, done from nature by the help of a microſcope, accurately repreſents.

The Mite having thus made itſelf ready, concontracts its body with ſuch force, that from a circular, it becomes of an oblong form, Fig. IV. the contraction extending in a manner to every part of the body. This done, it again reduces itſelf with ſo prodigious a force to a ſtraight line, that its claws, which are ſeated in the mouth, make a very perceiveable noiſe on parting from the ſkin of the laſt ring of the body: and thus the Mite, by firſt violently bending, and afterwards ſtretching out its body, leaps to a moſt extraordinary height, if compared with the ſmallneſs of the creature, in conſequence of the ſtroke the body gives in recovering its place on the cheeſe, or wood, or any other ſubſtance upon which it was before lodged.

I have indeed ſeen a Mite, whoſe length did not exceed the fourth part of an inch, leap out of a box ſix inches deep, that is, to a height twenty-four times greater than the length of its own body *; others leap a great deal higher. But this Worm does not always erect itſelf perpendicularly to take a leap; it very often prepares for this when lying on its ſide, though the firſt is the commoneſt method; but whether it erects itſelf, or lies on its ſide when about to leap, it never fails to bend its body into a circle, and afterwards to reduce it to a ſtraight line.

If, Sir, you ſhould be deſirous of examining with your own eyes, theſe ſurpriſing miracles of God's power and wiſdom in this abject creature, you need only place the Mite in a drop of water, upon any white ſurface, and adapt it to the microſcope in this ſituation; for, though it cannot leap in the water, you may diſtinctly perceive it endeavouring to do ſo, by ſeizing its anus with its claws, and making every other poſture, exhibited in the ſecond, third, and fourth figures.

This may alſo be ſeen in another manner, by faſtening the Mite with a little paſte, made of ſtiff ſtarch, on the point of a very ſmall needle made for the microſcope, as it cannot looſen itſelf, ſo as to perform its leap in this ſituation. Another method is, to roll the Mite about a little upon a table, and handle it till it has loſt a great deal of its ſtrength; for, in this condition, it takes hold of its anus very irregularly, and ſometimes fixes its feet into the pulmonary tubes placed about that part; you may then very conveniently ſee in what manner it extends its claws upon this occaſion. Our common friend, Dr. Matthew Slade, will confirm all theſe particulars, he having had the pleaſure of admiring, together with me, all theſe prodigies of nature.

An anatomical deſcription of the internal parts.

To kill ſome of theſe Worms for diſſection, I threw them into rain water, where they died, but not till after ſix or ſeven days: they are fitteſt, however, for anatomical diſſections, at the end of two or three days, lying in water; for though ſtill alive, they are benumbed. On being taken out of the water, at the end even of five days, they will crawl, however, and ſometimes leap about as briſkly, in a manner, as ever, and ſometimes live after this to become Nymphs, and afterwards Flies.

I could diſcover no eyes in the Mite's head; but the firſt things that preſented themſelves in that part, on diſſection, were the claws, which I before mentioned by the names of teeth and legs, as indeed I have found by experiment, that they will anſwer the ſeveral purpoſes of all thoſe parts. The inſect makes uſe of them as teeth, in ſcraping off the cheeſe, and afterwards ſwallowing it, ſo that it is but reaſonable to call them by that name: next the Mite employs them to walk with, ſo that one would imagine it walked upon its noſe. This may be ſeen, by placing it upon a piece of fine linen, or paper; for it fixes theſe two parts into the pores of the linen, or paper, and then draws after them the reſt of its body. Thus they deſerve the name of feet: but this is not the only manner in which this creature crawls; it can likewiſe move itſelf by an undulation, or waving motion, of its body. Finally, theſe parts, may be juſtly conſidered as claws, not only upon account of their reſemblance to thoſe parts in other animals, but alſo, becauſe it is with them that the Worm takes hold of the laſt ring of its body, ſo as to bring its mouth and anus to meet together.

Theſe teeth or claws are very ſharp on their fore part, and they are moderately crooked, almoſt like thoſe of hawks and eagles, Tab. XLIII. Fig. V. *a a*. Nearer the root they grow broader, and they have two apophyſes or ſwellings, wherein the muſcles, that ſerve to move them, are inſerted. Theſe teeth are articulated with the mouth and palate, which are two little black, oblong, hollow, horny bones, with which the pharynx is alſo connected. Theſe little bones, from a ſlender beginning, *b b*, afterwards become broad, and at laſt terminate in four appendages, *c c*, which are in a manner of a membranaceous ſubſtance: but in the fore part, they are connected in the middle, with two other horny, and very ſingular bones, *d*, which ſerve to keep them in their places, and at a proper diſtance from each other.

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* We may admire in this inſtance the powers nature has given to different creatures, and their limitations, to anſwer neceſſary purpoſes, and not for miſchief to mankind. If nature had given this power to the ſerpent kind, how terrible would it have been! A Viper would have thrown itſelf from a concealed place, ſeventy-two foot at the traveller; a Rattleſnake an hundred and fifty: this being the proportion to the length of their bodies.

The gullet, which lies between theſe appendages of thoſe little bones I have been deſcribing, and in their hollow part, becomes conſiderably wider in the Worm's thorax, *e*, where it, in a manner, forms an ingluvies or large hollow.

Under this are ſeen four appendages, cloſed at their ends, *ff*, which are, as it were, cluſtered about and ſurrounded by little globular particles of a fatty matter, but of a peculiar nature. They are indeed properly made up of theſe. As yet I cannot determine what theſe particles ſhould be called, or the uſe of them may be, unleſs, perhaps, they may ſerve to moiſten the food of the Worm, in its paſſage through the œſophagus or gullet, and thereby render it of eaſy digeſtion.

The ſtomach, *g g g*, offers itſelf next to our conſideration. It is very long, as is the caſe in all other inſects, while they continue in the Worm or Caterpillar ſtate. It is ſupplied with a great number of ramifications from the windpipe; but I have omitted them all in the figure, except two principal, and ſome other ſmaller, ramifications diſtributed over the ſurface, *h h h*. The length of this ſtomach is ſo very conſiderable, that one might eaſily miſtake it for a gut, and deſcribe it as ſuch; and no doubt, I ſhould have been myſelf of that opinion, had I not had an opportunity of comparing together the conſtruction of this, and of the ſtomachs of other inſects. This ſtomach is of a membranaceous ſubſtance, in which there appear ſome muſcular fibres through its tranſparent coats. All the contents of the ſtomach were white: I have endeavoured to repreſent them in the figure by ſome dots, as ſeen through the coats of the ſtomach, *i*. The ſtomach appeared alſo inveſted with numerous particles of fat; but I did not diſcover this laſt circumſtance in the ſtomach, till after I had dried it on a thin piece of glaſs.

Lower down, towards the end of this channel, there riſe from it two little ſlender inteſtines, *k k*, like thoſe found in all other Worms or Caterpillars, that I have yet diſſected, and even in the Louſe. I call theſe cæca, or blind inteſtines. In the Mite, theſe two inteſtines divided, each into two others; two of theſe contained a greeniſh yellow ſubſtance, *l l*; and the two others, a matter that was partly green, and partly white, and looked as if it was coagulated, *m m*; but what was very ſurpriſing, the motion of this ſubſtance through the inteſtines was ſo quick, that my eyes could not keep up with it; and, on my cutting one of the inteſtines in two, it flowed from it with great rapidity. This I obſerved in a live Worm, that I diſſected; but in another, which began to putrify, I found the coat of this inteſtine diſſolved into an infinite number of little fatty lumps. In both, theſe inteſtines were of a prodigious ſmallneſs; but from the motions of the matter contained in them, we may reaſonably conclude they are furniſhed with muſcular fibres, though I could by no means obtain a ſight of them, as they evade by their extreme delicacy, the ſharpneſs of both our eyes and inſtruments, which are at beſt only fit to examine viſible and ſenſible objects, and even theſe very imperfectly. How much therefore are we bound to humiliate our hearts, when, on account of our great weakneſs, we cannot thoroughly ſearch into any one of God's creatures! Theſe inteſtines had alſo their pulmonary tubes, *n*. And who can tell how many more wonders may yet remain hid in them!

The pylorus, *o*, or opening of the ſtomach, appears below the inſertion of the four inteſtines I have been juſt deſcribing, and near to this is the gut colon, *p p*, which is followed by the rectum, *q*. I could diſcern the very extremity of the rectum, *r*: it was of a ſomewhat different form from that which I have given it in the figure; for I there repreſented it as it appeared on my ſqueezing it at the fundament out of the Mite's body.

It is extremely remarkable alſo, that two of the cæca or blind guts, were ſo united with particles of fat, *s s*, that their cloſed extremities appeared firmly fixed in them, and connected with them by means of a great number of pulmonary tubes. In the figure I have only repreſented this circumſtance in one of the inteſtines. There are in this creature a great number of theſe particles of fat. They are of an oblong oval form, ſometimes double, and ſometimes hung about with appendages, round, hollowiſh, and flat, as may be ſeen in the two little portions of this fat, which I have here repreſented, *s s*.

On examining this fat with a powerful magnifier, every diviſion or lobe of it appears wrapped up in its own particular membrane. We may, even by this means perceive, that every ſingle particle of this kind, contains an infinite number of globules of fat, Fig. VI. *a a a*, which flow out of the lobe as ſoon as it is opened, and mix confuſedly together; ſo that, a variety of branches, compoſing, as it were, a little tree, are formed by the combinations of the concurrent lobes. The particles of this fat are of a duſky white, and, by this means, they exhibit in the Worm a ſpectacle, whoſe beauty no words can properly deſcribe; but we need not think this extraordinary, as it is effected by the Omnipotent Being, who, with a word, produced all things.

It is very entertaining alſo, to conſider in what manner the pulmonary tubes, which are of a bright ſilver whiteneſs, Fig. VI. *b*, run every where, and in every poſſible direction, through theſe pinguiferous or fat veſſels, ſo as to diſtribute themſelves principally over the particles of the fat, where this ſubſtance is laid up in little round lumps; at the ſame time, that in the interſtices of theſe lumps, they run into one another without any apparent order.

On one ſide of the gullet, there lay a very delicate and ſmall tube, ſtretching to the jaws, and the horny bones conſtituting the palate and mouth; but I have not as yet been able to trace this tube perfectly to its origin. I found that it divided itſelf, in the breaſt, into two ſmall channels, each of which widened again into an oblong globular bladder, Fig. V. *t t*, and then became

came again contracted into a narrow tube, which reaſſumed once again the form of a bladder, beautifully adorned with a great number of pulmonary tubes running over the whole ſurface, *u u*. Some particles of fat very regularly placed, and moſt curiouſly contrived, ſurrounded one ſide of theſe glandular veſſels, *x x*, and underneath, extended into a kind of blind or cloſed appendages, *y y*, ſuch as I had never obſerved before in the fat of any creature.

Nor can I tell the uſe of the particles laſt deſcribed, though I have reaſon to think they perform the office of ſalival glands and ducts. For, as the Mite ſpins no web, and theſe baggs are cloſed behind, I do not think any other ſervice can be ſo properly attributed to them.

The pulmonary tubes, which are diſtributed through all the parts we have been ſurveying, are conſtructed in the Mite after the ſame manner as they are in other inſects. That great anatomiſt Malpighi, has given an inſtance of this in his account of Silkworms; and I have, myſelf, frequently done the like in this work. But the rings compoſing theſe tubes, are not ſo very numerous; for which reaſon, they are of a more membranaceous and flexible ſtructure.

The motion of theſe pulmonary tubes is ſeen very evidently through the ſkin, on examining with a microſcope the Mite, held on the point of a pin run through its head; for, as the inſect in this condition turns and twiſts itſelf a great many ways, the pulmonary tubes aſſume, in conſequence of its motions, a variety of appearances. Sometimes they are ſtretched out to their length, at other times they are bent in a ſerpentine manner, or coiled up in form of a circle; but notwithſtanding ſo many diſtortions, the rings compoſing them always retain their form, and never collapſe. Thus has the Omnipotent Architect given us the ſpecimen of a tube, ſo perfectly flexible, that the moſt violent contortions cannot do it the leaſt injury.

The brain is ſituated in the neck, near the horny bones, that form the mouth and palate of the inſect. This ſituation of the brain makes it fall lower in the neck, on the Worm's pulling its feet into its mouth; and, on the contrary, it is drawn forward, as often as that creature thruſts out its ſnout: this is very much the caſe alſo in Snails. What atheiſt is there, who would not be confounded and ſtruck dumb, on examining attentively the wonderful contrivance in the viſcera of animals? For my part, I dare challenge mankind to deſcribe properly the ſmalleſt portion of the meaneſt creature that crawls upon the earth. Whoever ſhould undertake ſo bold a taſk, would loſe his eyes in the attempt. For, there is no doubt but any one, who, in this vale of tears and ignorance, ſhould fully and immediately behold the divine ſun of theſe truths, which God has treaſured up in his creatures, would forfeit ſight for his preſumption. Such has been the unhappy, though deſerved fate of all thoſe, who have attempted to diſprove and overturn by human reaſonings, and ſenſible experiments, the divinity of the Creator, ſo clearly ſhining forth in the whole nature of things. Whatever is a ſenſible object, muſt lie within the ſphere of the ſenſes; but our ſenſes are coarſe, and cannot of themſelves teach us any truth, unleſs prior ideas of it have been impreſſed upon us by him, from whom we derive our exiſtence. This, father Malabranche has moſt inconteſtably proved in his inquiry after truth.

The brain in the Mite conſiſts of two globular parts, which in a manner conſtitutes its right and left portions, Tab. XLIII. Fig. VII. *a a*. Near the brain is ſituated the beginning of the ſpinal marrow, which in this place is always opened, ſo as to give a paſſage to the gullet. From the fore region of the brain there iſſue ſome conſiderable nerves, which dilate a little, at the diſtance of half their length from their origin, *b b*. But this particular is not obſervable in every Mite. Theſe nerves at length ſwell into two diſtinct and very conſpicuous nodules, *c*, from which ariſe two ſmaller and very delicate nerves, *d d*. I could not trace theſe far enough to know what parts they run to: I believe it is to the muſcular parts of the mouth, palate, and feet. Next under the brain, and from the beginning of the ſpinal marrow, there ariſe two pair of very ſlender nerves, *e e*, which adminiſter to the viſcera in the abdomen, and to the muſcles moving the rings of the body. Under theſe appear two conſiderable nerves, which, after dilating into two oblong globes, *f f*, cloſe again, and then form two other globes, ſmaller than the former; from which there ariſe again two nerves: but what theſe nerves are, or what purpoſes they ſerve in this inſect, I cannot tell. I believe, indeed, they exiſt uſeleſly in the Worm, and are to work the muſcles of the wings, when it becomes a Fly. From each ſide of the ſpinal marrow there iſſue a great many other delicate and ſmall nerves, *g g*, which are all diſtributed to the inner parts of the creature, and to the muſcles of its body; and many of theſe nerves ſubdivide into various ramifications, *h h h*.

The ſpinal marrow will appear very ſhort, if we compare its length with that of the entire inſect; and the ſame may be ſaid of the body of the Fly into which the Mite turns. It is therefore neceſſary, that the nerves, which are extended to ſo great a length, ſhould contract themſelves, and become ſhorter, at the time that the Worm begins to change to a Nymph. In animals, whoſe blood is of a red colour, ſuch as Dogs and Calves, I have often obſerved, that the nerves ſhrink up, as Serpents do, into rings, or like a ſpiral, as often as the part to which they are fixed undergoes any contraction: and this is chiefly obſervable in the nerves of the meſentery; whereas in the Worm now before us, the nerves are in every part equally contracted. This likewiſe happens in the Coſſus, or Worm of the Beetle, where this contraction affords a very uncommon and very entertaining ſight.

The ſpinal marrow of the Mite conſiſts of twelve diviſions, or, as it were, nodular ſections. Theſe, however, are ſcarce diſcernible, on account of their ſmallneſs, being no larger than grains of ſand. This part is inveſted with a moſt delicate coat, through which are ſpread a great many pulmonary tubes: it is beſides covered with particles of fat, which I have endeavoured to repreſent by dots on the figure of the marrow. All the nerves iſſuing from the ſpinal marrow are covered with a continuation of the ſame coat, which inveſts the marrow itſelf; and they are likewiſe furniſhed with pulmonary tubes, which accompany them in their moſt delicate ramifications.

The ſpinal marrow, viewed ſideways, has quite a different appearance from that which the figure here given of it repreſents; for, on looking at it in this manner, it appears ſituated lower than the brain, Tab. XLIII. Fig. VIII. *a*, and looks ſomewhat crooked, *b*. This form, I am inclined to think, was purpoſely contrived to allow a freer paſſage to the gullet, where it runs down, like an inteſtine, from the jaws to the ingluvies, or ſwallow. This is the reaſon why the brain is placed above the gullet, and the gullet, together with the ſtomach, reſts upon the ſpinal marrow, and its nervous ramifications: ſo that, properly ſpeaking, the ſpinal marrow reſts upon the muſcles of the rings of the body in the under part, and is cuſhioned up with particles of fat on every ſide.

The conſtruction of the muſcles, which in this inſect move the rings of the body, is very ſingular and ſurpriſing. I diſcovered three different kinds of them, without examining farther than the foremoſt part of the thorax; ſome deſcending obliquely with two bellies, Tab. XLIII. Fig. IX. *a a a*; ſome broad ones run croſſways, *b b*; and others again aſcend obliquely, *c c*. All theſe muſcles are ſo elegantly ſituated, that the greateſt adepts in deſigning and painting, I am certain, muſt confeſs their inability, were they to go about repreſenting them as they deſerve to be figured. To exhibit exactly every thing worthy of notice contained in theſe parts, we ſhould be obliged to make uſe of figures twenty times larger than theſe now before us. And, after all, the muſcles which I have called the obliquely deſcending, and which have two bellies, do not, properly ſpeaking, deſerve that name; for they appear to have five tendons, of which one is inſerted into the muſcle that lies next to it, and the other four into the tough rings of the body, which they ſerve to move, as I have endeavoured to repreſent, if the unſpeakable magnificence of God's works can at all be repreſented by human art. An infinite number of pulmonary tubes are diſtributed all over theſe muſcles; but, as yet, I have not been able to diſcover in them any inſertions of the nerves: ſo that I muſt, in this point, own myſelf as much at a loſs, as I have upon many other occaſions.

As to the heart, which ſends the white or aqueous blood of this little creature, in a due circulation, through the body, I could by no means diſcover it; and this I attribute to its ſmallneſs, and to its being of a thin and delicate ſtructure. But I am perſuaded, that it lies in the upper part of the back, like that of Silkworms; for I could plainly diſcern pulſations in that part.

An account of the manner in which Mites get into cheeſe, and cauſe it to rot, inſtead of being cauſed by or formed themſelves out of rottenneſs; with many other uncommon obſervations.

THE parts I have hitherto mentioned and deſcribed, are all I have been as yet able to diſcover in this minute inſect. And now let the ſharpeſt geniuſes, and men of greateſt penetration and learning, judge if a creature, in the fabrick of which there plainly appears ſo much art, order, contrivance, and wiſdom; nay, in which is ſeen the hand itſelf of the Omnipotent God; could poſſibly be the production of chance or rottenneſs! Is not the light of human underſtanding alone, unaſſiſted by divine revelation, ſufficient to convince us, that it cannot be ſo? Certainly it is ſufficient. The illuſtrious Redi as evidently proves, that this ſyſtem of the production of animals from putrefaction, aſſiſted, as they would have it, by heat and moiſture, is a mere idle imagination, founded on the erroneous maxims of heathen philoſophers, unacquainted with any ſuperior origin of exiſtence.

That ingenious naturaliſt moſt accurately explains in what manner Mites proceed from Flies, which have depoſited their eggs in the cracks and holes of cheeſes*: and I can add to his account, that the body of theſe Flies terminates in ſo fine a point, that they are able to thruſt it into, and penetrate very deep in, the ſmalleſt openings. I cannot but alſo take notice, that the rottenneſs of cheeſe is really occaſioned by theſe Worms; for they crumble the ſubſtance of it into ſmall particles, and void their excrements in it, and foul it with their ſaliva, or the moiſture of their mouths; ſo that the ſmalleſt ſpot of rottenneſs, produced by theſe inſects, cannot but immediately ſpread itſelf. I once obſerved a cheeſe, which I had purpoſely expoſed to this kind of Flies, in order that they ſhould lay their eggs in it, grow moiſt in a ſhort time, in thoſe parts of it where theſe eggs had been depoſited, and had afterwards been hatched into Worms, though before the cheeſe was perfectly ſound and entire. I have likewiſe obſerved, that this putrefaction in cheeſe is conſiderably augmented by the carcaſes of the Worms that happen to die in it; for there always die ſome of them: and it is impoſſible there ſhould not, as it is a certain death to them not to be able to harden into Nymphs, and all of them cannot eſcape out of the moiſt part of cheeſe to a drier ſituation, which is neceſſary to ſuch a change. Further, I have obſerved, that ſome of theſe Worms contained other Worms within their bodies, but ſo minute as to be ſcarce diſcernible. But, on extracting theſe ſmaller Worms from their places, I found they were almoſt of the ſame form with the larger Worms, though they move themſelves from place to place in quite a different manner. I could even diſcover, in the tranſparent bodies of theſe ſmaller Worms, that, by examining with the microſcope, notwithſtanding their almoſt incredible miutenеſs, they were furniſhed with pulmonary tubes, and other parts in common with the greater.

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* This ſpecies of Maggot, though altogether different from what we call the Mite, is not uncommon in large cheeſes, particularly in ſuch as have not been well made, and have fermented. In ſuch cheeſe, where it is moderately ſoft and damp near the ſurface, theſe Maggots are frequent; and if they fall off, on being diſturbed, they will leap about, upon a diſh or table, in a ſurpriſing manner.

It is certainly very difficult to explain in what manner Worms are bred in living animals; as, for inſtance, in the livers of Oxen, in the kidneys of Dogs, and even in the blood-veſſels, as is obſerved by that celebrated anatomiſt and profeſſor of ſurgery at Amſterdam, Ruyſch. For my part, I freely own, that I want ſufficient experiments to form any ſolution of this ſurpriſing phenomenon; though I have met with great numbers of different kinds of Worms, in the living and healthy bodies both of land and water animals, and even of fowls and flying inſects. However, on this occaſion, I cannot as yet advance any thing certain, or ſatisfactory.

I muſt not omit a circumſtance which I heard from Otto Marſilius, the late famous painter of flowers and inſects. It was this, that he had ſeen, at the time when Caterpillars were buſy in diveſting themſelves of their ſkins, or when they had juſt performed the operation, and were grown faint and weak with the fatigue of it, a great many Flies, ſome bigger and others leſs, piercing the bodies of ſuch Caterpillars, and depoſiting in the wounds, ſo made, quantities of little eggs; from which proceeded the Worms, that are every year ſo commonly found in Caterpillars. As yet, I muſt own, I never ſaw myſelf this ſtrange operation: but allowing it to be fact, it would perhaps greatly help us in explaining the generation of Worms found in the viſcera, or bowels, of larger animals; provided eſpecially ſuch Worms were found afterwards to turn to Flies, or other winged inſects, which as yet I have not been able to determine experimentally, notwithſtanding the pains and attention I have beſtowed on the obſervations of changes in this kind. Admitting Marſilius's account to be true, and that ſome of the perforations he obſerved were made into veins and arteries, and eggs were depoſited in ſuch perforations, there can be no difficulty in conceiving how the circulating blood might have diſperſed theſe ſeeds of animals all over the body. It muſt however be owned, after all, that theſe things are as yet buried in a cloud of darkneſs, which obſcurity, nothing but the brighteſt light of experiments can ever diſpel. In the mean time, we may ſee, by the manner in which we are affected by the ſtinging of a Bee, how an animal, without getting into our bodies, may convey a matter into it, capable of producing great alterations; for the Bee, at the ſame time that it gives the wound, inſinuates by it into the body a drop of poiſon. This is not a place for explaining how eggs come to be found in the ſubſtance of plants; beſides, that I have already ſufficiently treated of that ſubject.

As to the opinion of ſome people, that the Worms found in our inteſtines proceed from the eggs of animals which we have ſwallowed, it only deſerves contempt, being altogether contrary to ſound reaſon; unleſs the favourers of that ſyſtem would at the ſame time allow, that the eggs ſo ſwallowed are thoſe of Worms bred in the inteſtines of other animals. This opinion cannot by any other means be admitted, as it is quite inconſiſtent with the nature of things, that an animal ſhould live for any time in a ſituation ſo different from that in which it naturally ſhould live, and on ſo different a food. Beſides, for this to be true, it is requiſite that ſuch Worms, intended for living in other places, ſhould alſo be able to endure the heat of the inteſtines, and of the fluids paſſing thro' them. A thing which no man in his ſenſes can admit.

The generation of animals, or the laying and hatching of their eggs, is by no means a thing which requires little care or attention. Every creature has its own ſeaſon, its own haunts and element, its own manner of living, and its own food. Every year we obſerve the ſame renewals of the ſeveral ſpecies, performed in a manner limited by a conſtant and inviolable law and order of Nature; as the illuſtrious Redi, before mentioned, has, on another occaſion, likewiſe obſerved. For this reaſon we always ſee, that Worms of the ſame kind, found in the inteſtines of animals, have conſtantly their blood of the ſame colour, be it red, yellow, green, or white.

In regard to Caterpillars, indeed, I have obſerved four different ways in which Worms lie hid within their bodies, and afterwards creep out of them *. The firſt is, when one or more Worms make their way into the Caterpillar,

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* The caſe in thoſe Flies, which we ſee hatched out of Chryſalis's, from which we expected Butterflies, is exactly the ſame with thoſe produced from galls, and the other excreſcences of vegetables. The parent Fly is guided by inſtinct to lodge her eggs in the body of the Caterpillar, piercing its ſkin, for that purpoſe, with a ſharp inſtrument at its tail. I have ſeen the operation; and the miſery of the Caterpillar, which can no way eſcape from its winged enemy, is terrible. All the variation in number of the young, and other accidents, is owing to the different ſpecies of the Flies.

pillar, kill it by their corroding, and afterwards make their way out again through, the ſkin. The ſecond way is, when two or three Worms lay hold of a Chryſalis, and, after killing the encloſed animal, eſcape in the ſame manner. In the third way, the Worms, after depriving the Caterpillar of life and motion, eat up all its inſide; and, this done, they bore or gnaw themſelves holes to creep out at in its hardened ſkin. Fourthly, when one or many Worms treat a Chryſalis in the ſame manner exactly, in which the Caterpillar is treated in the third way.

There are ſeveral other things to be conſidered in this place. Firſt, when the Caterpillar happens to be killed by a ſingle Worm, which afterwards fixes its reſidence between that creature's body and its web, then the Worm ſpins itſelf another white oval web, in which it changes to a Nymph, and afterwards to a Fly. But if the Caterpillar is deſtroyed, and perforated by a number of Worms, then theſe Worms ſettle themſelves under the belly of the dead Caterpillar; where each of them makes itſelf a gold-coloured web, in which they caſt their ſkins, then become Nymphs, and at laſt aſſume the form of Flies.

Secondly, when two or three Worms eat into a Chryſalis, and afterwards creep out of it, they do not, immediately after ſo doing, caſt their ſkins, but only contract their bodies: and while they are in this ſtate, they aſſume, in an orderly manner, and with a conſtant regular ſucceſſion, thirteen different colours; the laſt of which, alone, they finally retain. At laſt, they turn to Nymphs within their old ſkins, and then to two or three common Flies.

Thirdly, the Worm which ſingly takes poſſeſſion of a Caterpillar, and, after having eat up all its inſide, remains within the ſkin; ſometimes makes itſelf a web within this ſkin, and then becomes a Nymph, and at laſt changes to a Fly like the baſtard Waſp, Pſeudo-ſpheca, or Ichneumon-fly. In this caſe, we always find ſome excrements within the Caterpillar's ſkin; as likewiſe the two ſkins which the encloſed Worm has ſeverally thrown off, on turning to a Nymph, and then to a Fly. But the minute Worms, which remain in the Caterpillar they have deſtroyed, make no web in it; though they grow to Flies, in the ſame manner with the Worms producing that kind of baſtard Waſp juſt ſpoke of, and then gnaw themſelves holes to make their eſcape.

In the fourth place, the Worm, which remains ſingly in a Chryſalis, makes alſo a web within it, voids its excrements there, and then changes to a kind of baſtard Waſp, in the ſame manner with the Worm juſt now mentioned, as living ſingly within a Caterpillar. If you open the ſide of this emptied Chryſalis, before the encloſed Worm changes to a Nymph, it immediately ſpins a patch againſt the broken part. But when many Worms are placed together in a Chryſalis, they neither make themſelves webs, nor do they even contract themſelves, but only change to a great number of ſmall Nymphs, which afterwards turn to as many Flies. Theſe Flies, which are of a moſt elegant ſtructure, ſometimes gnaw themſelves one, and ſometimes more holes, for their eſcape, in the dried ſkin of the Chryſalis.

All theſe things proceed every year in ſo conſtant, certain, and regular a manner, that no accident whatſoever can alter the courſe of the operation. One very ſingular inſtance of this unchangeable order in nature, is, that even the Caterpillars and Chryſallides, which are to become the ſcenes of the laſt mentioned changes, may be eaſily diſtinguiſhed from the other inſects of the ſame kind. In the firſt mode of theſe mutations, when the Worms, which have lodged, many together, in a Caterpillar, place themſelves under its belly, the Caterpillar raiſes that part, to make way for them; and though, by this time, it has received its death's wound from thoſe cruel invaders, it notwithſtanding, with the greateſt care and attention, encloſes and connects all their particular webs, within one of its own ſpinning, for fear they ſhould be ſcattered abroad and loſt, and after this expires.

From hence we may reaſonably conclude, that if the Worms had thus lodged in the Caterpillar, and killed it, merely by accident, inſtead of doing both, in conſequence of an immutable decree of the All-governing Power, the Caterpillar, when it found itſelf ſo roughly treated by them, would by no means take this regular care to ſecure them from rain and winds, and thereby inſure the renewal of that particular ſpecies of inſects; for they generally turn to Flies the year following.

The ſame order is obſervable in all the other perforations, deſtructions, and excavations of Caterpillars and Chryſallides, which I have already taken notice of, ſo that we can only aſcribe to our own raſhneſs and ignorance that erroneous notion, of putrefaction being able to perform wonders worthy of the Deity, and to which the power of the Deity alone can be rationally deemed equal. It is therefore in the higheſt degree ſurpriſing, that all mankind, the learned as well as the ignorant, ſhould have ſo readily adopted, and ſo long entertained, ſo groſs an error; eſpecially as the leaſt degree of reflexion muſt have convinced them, it aroſe from prejudice; at the ſame time that the ſmalleſt diligence, in examining the works of Nature in themſelves, would have put them in the way of obtaining more juſt ideas on this ſubject.

Let us then be wiſer than thoſe who have gone before us, and accurately ſurvey and examine the ſenſible wonders of the Deity, with all their conditions and circumſtances, if we intend to obtain a true and ſolid knowledge of them. Let us not ſervilely ſubmit our judgments to the doctrine of Ariſtotle, and the reſt of the heathen philoſophers, who aſcribe to putrefaction, works that contain viſible marks of an all-perfect Contriver and Maker; tho' at the ſame time we are, as men, convinced by daily experience, and, as chriſtians, are taught to believe, that all the things we ſee are liable to decay and deſtruction. God's power and wiſdom is not to be ſeparated from his juſtice, ſince, according to the unerring teſtimony of his holy ſpirit, he has entered into a covenant with his creatures; and theſe, under their corruption, groan and ſigh after liberty.

That vulgar opinion, more worthy of brutes than of rational beings, which aſcribes the birth and growth of animals to putrefaction and chance, is diametrically oppoſite to ſound reaſon, and ſavours rankly of atheiſm. It has not even the leaſt ſhadow of experiment or obſervation to ſupport its truth; but is founded altogether upon ſloth, prejudice, ſtupidity, and error; all which is the more obvious, as in the ſmalleſt animals we conſtantly every where find as much order, contrivance, beauty, wiſdom, and omnipotence in the Great Architect, as are ſhewn in the viſcera or bowels of the largeſt animals. For to theſe greater animals all others, however contemptibly minute, if their minuteneſs can make them contemptible, are ſimilar in the great reſpects of brain, nerves, muſcles, heart, ſtomach, inteſtines, and parts ſubſervient to generation, and to every other uſeful purpoſe; ſo that one might in a manner affirm, that God has created but one animal, though divided into an infinite number of kinds or ſpecies, differing from each other in the figures and inflexions, and extenſions of their limbs; as likewiſe in their diſpoſitions, food, and manner of living.

As Caterpillars, which turn to Butterflies, often contain in them Worms which change to common Flies; ſo the Worms, which change to Beetles, very often contain in their viſcera alſo certain Worms, that turn to Beetles of a ſmaller kind: and, in theſe changes, Nature obſerves the ſame conſtant order and method, as in the firſt. From hence I again conclude, that nothing is produced by putrefaction; but that the buſineſs of generation unalterably proceeds in a certain and regular manner. And certainly, if our little philoſophers would attentively examine what is the nature of putrefaction, when it breaks out in an animal, or in any part of one, which thereby rots, and is reſolved into its conſtituent principles; and would withal conſider that ſpecies of putrefaction which Worms occaſion, and which they cannot but occaſion, in other bodies, or in ſome parts of their own; they would ſoon free themſelves from the yoke of ſo abſurd and ſlaviſh an opinion.

As yet, I cannot by any obſervation determine, whether the Mites, which are found to contain other Worms, are perforated by them, while they remain in the cheeſe, or after they forſake it, and turn to Nymphs. It is only within theſe ſix or ſeven weeks, that I have made the experiments concerning theſe inſects, which I have juſt now related, having never expreſly examined them before that time. However, in this time I could diſcover in the cheeſe a great number of dead and rotten Worms, of a red, purple, and livid colour, whoſe carcaſes not a little contributed to increaſe the ſtench and putrefaction of the cheeſe in which they lay, and likewiſe the acrid and peculiar taſte found in ſuch parts.

The manner in which Mites are changed into Nymphs *.

THESE Mites, when they are about to become Nymphs, generally deſert the cheeſe in which they had hitherto lived, by leaping up and down, till they find, if poſſible, a more favourable ſituation. In three or four days after this they looſe all motion, grow ſtiff, and harden. I have remarked alſo, that the change of theſe Worms may be forwarded by encloſing them, when well grown, in a dry box, without any thing to feed upon. In trying this experiment I have obſerved, that ſome ſmaller Mites remained alive in this confinement, without any food, for two or three weeks together; when they at length died, without turning to Nymphs; the embryo member hid under their ſkin not having attained the growth and firmneſs requiſite for that ſtate, which is obtained by the reſt in the following manner.

Firſt, the Mite draws up together the rings of its body, ſo as to make the interſtices appear full of wrinkles; and this contraction is ſo great, that the Worm becomes twice as ſhort as it was before, Tab. XLIII. Fig. x. This alſo renders the rings leſs diſcernible: however, the fore part of the head, Fig. XI. *a*, may be ſtill diſtinctly perceived, as well as the tubercules, *b*, at the other extremity of the body. As to the form of the little animal at this period, it ſcarce affords any thing worth particular mention; for the ſkin loſes its tranſparency. In this ſtate the Worm gradually changes its colour, till from white it becomes red, and in the end reſembles pure red lead.

The moſt experienced naturaliſt ſignior Redi, who has favoured the world with a ſhort hiſtory of the Mite, tells us, that its mutation agrees in nothing with that of Chryſallides, and other Nymphs, but he does not acquaint us wherein they really differ. Other authors conſider Mites at this period as eggs, though they have no other reaſon for thinking ſo, than a bare ſuppoſed reſemblance. This indeed, is ſo far from being even a ſuperficial one, in proper terms, that it can only be found in their own extravagant imaginations.

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* Let the reader be cautious not to extend what is here ſaid of the Nymph of the Mite, and its change into a Fly, to the common little inſect, uſually called a Mite by us; that is, an inſect which is hatched perfect from the egg of its parent, and undergoes no change, but only grows larger. This ſtate of change belongs to the offspring of all winged inſects, and to no others. Therefore it is neceſſary, according to the univerſal law of Nature, that this Maggot ſhould undergo ſuch a change, and that the Mite ſhould not.

They pretend to ſee things, which never exiſted, and they well deſerve to be compared to thoſe perſons, who, ſometimes, with equal truth, think they diſcover armies in the clouds, which were never formed but in their own diſturbed imaginations.

For my part, I call this change, by the name of the Vermiform-Nymph; becauſe, in this ſtate, the creature externally reſembles a Worm, and is at the ſame time really a true Nymph, and not a Chryſalis, under the former Worm's ſkin, which it ſtill retains together with the internal figure of a Worm. And accordingly, the limbs of a latent Nymph, appear, in ſome meaſure through, to a careful examiner, this ſkin. But I have already ſufficiently explained this fourth order of mutations in its proper place.

The Nymph, thus concealed under the ſkin of the Mite, is of a moſt elegant form. But to have a diſtinct view of it, 'tis neceſſary to break this ſkin, and then ſtrip it off from the Nymph. This muſt be done with great dexterity and circumſpection. By this means, we at laſt obtain a ſight, and a beautiful one it is, of the head, thorax, and abdomen of the future Fly, as I have repreſented them of their natural ſize, Tab. XLIII. Fig. XII. But to perceive them diſtinctly, we muſt uſe a microſcope; with the aſſiſtance of that uſeful inſtrument, we diſcern its two little horns, Fig. XIII. *a*, growing out of the forepart of its head, and under them its two eyes, *b b*, which take up the greateſt part of the head. Under the eyes lies the proboſcis or trunk, *c*, with all its parts. Near the proboſcis appear the firſt pair of legs, *d d*, and under the firſt pair the ſecond, *e e*, diſpoſed in a very beautiful order. The rings neatly folded up, *f f*, preſent themſelves next, and under them, we may ſee in what manner the hinder pair of legs, *g g*, lie ſtretched againſt the abdominal rings of the body, *h*: theſe, with the extremity of the anus, are very diſtinctly to be ſeen. In fine, all theſe parts are arranged together, with ſo much art and beauty, that it is impoſſible to give a juſt deſcription of them. They will be ſeen yet a great deal more diſtinctly, by diveſting the Nymph of the ſkin that immediately encloſes it.

At firſt all theſe parts are of the colour of coagulated milk, but as fluid as water, which makes it very difficult to ſeparate them; nor can they, after all, be accurately diſtinguiſhed one from another, becauſe they are at this period, all of the ſame colour. In ten or twelve days, they acquire ſo much conſiſtency, and ſo much of their peculiar colouring, as to aſſume the form of a complete Fly, on throwing off the internal membranes that cover them, within the former Worm's ſkin, which they ſtill retain for twelve days longer; when the new inſect, having acquired ſufficient ſtrength to appear abroad, breaks this external encloſure likewiſe, and launches into the air, in the following manner.

The manner in which the Nymph of the Mite breaks from its membranes, and aſſumes the form of a Fly.

THE firſt thing obſervable in this change is, that the Vermiform-Nymph loſes its deep red colour, and grows much darker; then the Nymph itſelf breaks that part of the ſkin, which covers its head into two parts, Tab. XLIII. Fig. XVI. *a*, *b*, and at the ſame time throws off from every part of its body a very ſlight membrane, which it leaves within the old ſkin. When this is done, there breaks out from under this ſkin, a little inſect like a gray Fly, without wings, but ſo nimble, that it runs immediately about as if it were ſeveral weeks old.

Sometimes after this, the new born Fly rubs with its forefeet, that part of its head which lies immediately over its horns; for, on this ſpot, there ariſes a conſiderable ſwelling, with a violent pulſation in it. The Fly never gives over rubbing, till it has diſperſed the ſwelling, and made it entirely diſappear. 'Tis probable, that it was in this part, the fore-legs lay while the inſect remained in the Nymph-ſtate. The next thing the Fly does, is to rub very gently with its hinder-legs, the ſurface of its two ſhort little wings, which are as yet folded up, till it thoroughly expands, and diſplays them. This operation may be very diſtinctly ſeen, and I have repreſented the great folds, Tab. XLIII. Fig. XIII, *f f*, which the inſect thus expands. The Fly, after this labour, takes a little reſt, remaining quiet until the wings fully diſplay themſelves, which is performed very ſuddenly, for their veſicles are no other than ramifications of the windpipe, which run up and down through them; ſo that we may eaſily conceive how they may be ſo ſuddenly expanded by an injection of blood and air from the main trunk. The inſect, however, cannot as yet fly; its wings yield ſome blood if they be wounded at this time; whereas, when they are once perfectly dried, which is done in a quarter of an hour, it is impoſſible to obtain the leaſt drop of blood from them, even by cutting them off, the veſſels being in that time perfectly dried up and cloſed; for my part, I firmly believe that all the membranes of animal bodies are no other than a kind of webs, conſiſting of veſſels conſolidated in this manner, as may be ſeen in the blood-veſſels of the epidermis, which dry up as ſoon as the fœtus comes from the womb, and ceaſes to draw nouriſhment from that part of its covering.

The Fly produced from the Mite is one of the common kind; and it affords very few things worth our notice: this may be ſeen by the two figures, in which I have repreſented it of its natural ſize, Fig. XIV. The wings, when they lie on the body, extend beyond the extremity of it. I give alſo a figure of the male, after a drawing taken with the microſcope, in which the head, thorax, and abdomen are ſeen very diſtinctly. On the forepart of the head, there ariſe two ſhort horns, Fig. xv. *a*, each with a ſtiff hair growing out of it. Near the horns appear the eyes, which are red, pretty large, and of a reticular net-like form; between the eyes, there ſtretches along the middle of the head, a black zone or prominent ſtreak, in which are placed three ſeparate and diſtinct eyes in the form of a triangle. Theſe are much more diſcernible on the Fly's firſt appearance in the air, than afterwards, as the ſtreak or zone juſt mentioned requires ſome time to grow black, and has, beſides, ſome hairs on it, which do not erect themſelves, till, by drying, they become ſufficiently firm for that purpoſe.

The thorax is covered with ſtiff hairs, of a brown colour, but of a poliſhed and ſhining ſurface, like a looking-glaſs. From its lower part riſe ſix legs: the firſt or fore-pair of them, *b b*, are almoſt black: in the ſecond pair only, the joint near the breaſt is of this colour; and the other two extreme joints, *c c*, of a dark brown. The third pair, *d d*, very nearly reſemble the firſt: but theſe colours are not exactly the ſame in all the Flies of this ſpecies. All theſe legs are covered with ſtiff hairs, and are each of them armed at their extremities with two claws, by means of which the inſect runs very nimbly upon glaſs, by darting them into the pores of it, not but that it can walk very well when thoſe nails are cut off; but then, though its feet are moiſt, it cannot hang itſelf to ſo ſmooth a ſurface. The wings are two; they are of a beautiful conſtruction, and ariſe from the ſlope of the breaſt, *e e*; they are bordered with fine hairs, and the filaments which run through them like ſo many little nerves, are no other than ramifications of pulmonary tubes. The membrane which fills up the ſpaces between theſe ramifications, is likewiſe elegantly conſtructed: it is covered with little prominent papillæ, but a drawing ten times larger than this, would hardly be ſufficient to do juſtice to this and other wonders, diſcoverable in the wings of flying inſects. The hinder part of the thorax is, by way of ornament, ſurrounded with a little prominent border; near which appear two very ſmall oblong particles, with round heads, reſembling mallets or hammers: it is by ſtriking theſe little hammers againſt its wings, that the Fly makes the humming or buzzing noiſe that is peculiar to it *.

The body conſiſts of ſeven rings; it is covered with delicate hairs, *f*, and is of the ſame reſplendent dark brown colour with the thorax.

The female differs from the male externally, in nothing but ſize: but the genital parts of the two ſexes are very different, as I ſhall now endeavour to demonſtrate.

Of the genital parts of the male and female Mite-Fly, and the manner of their coupling.

THE Mite has a penis, two teſticles, ſeminal veſſels, and proſtatæ; and the female its ovary, its womb, and the parts naturally belonging to it. The penis of the Mite is ſo artfully contrived, that the ſeven wonders of the world together, cannot compare with it; nor is it ſurpriſing they ſhould not, they being the works of men, whereas this little organ is the conſtruction of an Almighty and all-ſeeing Architect. It is partly membranaceous, and partly of a ſubſtance between bone and horn; the length, and inflexions of it alſo, are ſo uncommon, that it is impoſſible to conſider it, without being loſt in aſtoniſhment.

That part of the penis, which conſiſts of a ſubſtance between bone and horn, is black, and extends only along one ſide of it, Tab. XLIII. Fig. xvii. *a*; but this is enough te give the penis great ſtrength and firmneſs, and to keep it always open, in readineſs to perform its duty. The other ſide of the penis is membranaceous, *b*, and conſiſts of many tranſparent rings and globules. The fore-end of the penis is alſo membranaceous and obtuſe, *c*, though I have ſometimes ſeen it pointed with ſomething like an articulation at its extremity. It generally, however, appears blunt and open. I cannot tell whether or no the penis can erect itſelf through this opening; but I know of a certainty, that the vulva of the female paſſes into the ſaid opening, ſo as to form a kind of copulation, quite different from that of other animals, in which the penis is received into the female external organ of generation. It was by meer accident that I diſcovered this ſingularity in the copulation of the Mite-Flies: on examining a female, which had died for want of food, in the very act of copulation, I found the penis of the Mite withered round the vulva of the female, where it had been applied; but was then ſo looſely engaged, that I eaſily ſeparated them.

The penis lies on the outſide of the body, and is very eaſily diſcerned, as it extends along the body, with only its right ſide covered by the laſt ring. It is elegantly coiled up, and reſembles very much the penis of Drakes, which is likewiſe folded up in the ſame manner. This bird, it ſeems, does not ejaculate its ſeed through any perforation within the penis, but by a furrow or channel on its outſide. This I have likewiſe found to be nearly the caſe in ſome other animals.

The other parts of the male Fly ſubſervient to generation, are likewiſe very well worth our attention, but they lie hid within the body. The firſt that offers itſelf to our conſideration, is the nervous root of the penis, *d*, which is of a very bright white, and reaches to the laſt ring of the inſect's body, where the external part of the penis is covered with very fine hair. This white root of the penis is bent in a very wonderful manner, and grows broader at its extremity, *e*, where it unites with ſeveral other parts, amongſt which the teſticles *ff* deſerve our particular notice, on account of their ſingular figure and conſtruction. They are of a pale brown colour, variegated with red; but the ſperm contained in them is white, and that, as well as the coat of the teſticles, appears thro' the microſcope, as if made up of little globules. The vaſa differentia, *gg*, next preſent themſelves. Theſe veſſels widen conſiderably at a little diſtance from their union with the teſticles, and reſemble, as it were, the two globoſe appendages of theſe parts, *hh*. There is ſo little difference between the other parts, that I cannot diſtinguiſh them from one another, though I take the longeſt of them, as appears by my drawing, *ii*; for the ſeminal veſſels, and the others, which are more globoſe for the proſtatæ, *kk*. All theſe parts are of a delicate whiteneſs, and they convey a ſeminal matter of the ſame colour to the cavity of the penis. Theſe are all the parts I have examined in the male Fly, as it was the Worm alone, of which I propoſed to take a full and accurate ſurvey.

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* The French call theſe two parts Balanciers, Balancers; and their ſyſtem is, that they aſſiſt in flying; and in ſome meaſure make amends for the want of another pair of wings. There is probability in this opinion, becauſe all two winged Flies have them; and none that have four wings. Theſe ſyſtems are not contradictory, for they may anſwer both theſe purpoſes.

The female, on the other hand, is furniſhed with a double ovary, conſtructed nearly in the ſame manner with that of Herrings. But I ſhall defer ſpeaking of theſe organs, till the external parts of the uterus are deſcribed. The female hides its vulva, and the extremity of its uterus, under the two laſt rings of its body, Fig. XVIII. *aa*. The vulva conſiſts of three joints, the firſt of which is oblong, and hairy at its extremity, *bb*, and is furniſhed in the middle with two little black horny bones, which help greatly in the protruding of this organ out of the body. The ſecond joint lies entirely within the firſt, as within its prepuce. It is naked, or free from hairs, and it ends in a horny bone, *cc*. The laſt joint, which, properly ſpeaking, conſtitutes both the vulva and anus, is perfectly black, and is compoſed of a horny bone, and a membranaceous ſubſtance, with here and there a few hairs, *d*. Theſe parts of the Fly generally hang out of its body, on its quitting the Nymph-ſtate, in order that they may dry to a proper conſiſtency; they then void a drop or two of a fluid, which looks like water mixed with chalk. The excrements afterwards, thrown out from theſe parts, look little balls with tails to them, and conſiſting of a ſubſtance that very much reſembles plaiſter of Paris.

In diſſecting this Fly, I found it contained an ovary divided into two partitions, each conſiſting of thirty-two oviducts, with four eggs in each, one pretty large, Fig. XIX. *a*. and three imperfect ones *b*; ſo that the ovary of this ſingle little creature contained no leſs than 256 eggs. Theſe eggs were white, oblong, and crooked; the colour of the ſmalleſt was watery. When viewed with a microſcope, they appeared to conſiſt, as it were, of little globules, and the oviducts ſhewed themſelves in the ſame manner. All theſe oviducts diſcharged their eggs into the uterus by two common paſſages, and the uterus conveyed them out of the body by a ſingle channel. I ſurveyed the other viſcera, or entrails lying thereabouts, but very ſlightly; ſo that I could only ſee that the fat that had exiſted in the Mite, was now almoſt totally waſted away, and that the inteſtines formed a great many more folds than they had formerly done, though they were grown conſiderably ſhorter, and lay now entirely on the abdomen. Nor were the eggs yet perfect, tho' the Fly I diſſected was four days old.

Flies are by nature of a very warm and luſtful conſtitution; ſo that the female, immediately after its firſt appearance in this form, and before it has changed its gray colour, invites the male to copulation. In this act, which laſts for a conſiderable time, the male always gets upon the female; and in this ſituation he is carried by her up and down like a man on horſeback. All this time the female keeps her wings expanded, and extending her vulva to that part of the male's body, where the penis lies, thruſts it into the cavity of this organ, which does not, upon this occaſion, ſuffer any erection. And this manner of copulation obtains in many other kinds of Flies, and likewiſe in ſome kinds of Hornets. It is very ſingular to obſerve how the male gently pats the female during this operation with his body, and preſſes himſelf upon her juſt as a Cock does with the Hen, tho' the copulation of thoſe fowls is very ſpeedily performed, and that without any abſolute corporal conjunction.

The Flies under our conſideration, are very ſtout and vigorous; ſo that it is no eaſy matter to deſtroy them by drowning: after lying in the water a conſiderable time, ſo as to appear quite deſtitute of life and motion, they will immediately recover on being expoſed to the ſun, and fly off as briſkly as if nothing had happened to them. They have two methods of flying; in the one their motion is ſlow and regular, and in the other it is rapid and diſorderly. I fed ſome of theſe Flies with new milk-cheeſe ſteeped in water, which they ſucked up thro' their trunk, or proboſcis. This uſeful and curious organ is placed on the lower part of the head, a little below the horns, or antennæ, and it conſiſts of three hairy joints. I likewiſe had the pleaſure of ſeeing them lay their eggs in a piece of cheeſe, and I found in a few days afterwards a number of Worms which had ſprung from thoſe eggs, perfectly reſembling thoſe of the firſt brood that had produced the parent-fly.

The manner in which theſe Flies lay their eggs; with an account of the membranes they throw off on leaving the Nymph-ſtate.

IT appears, at length clearly, by what I have obſerved concerning theſe inſects, how readily the females can lay their eggs in the ſmalleſt cracks of a cheeſe; and I have ſeen them myſelf thruſt out their tails for this purpoſe, to an amazing length, and by that method bury the eggs in the deepeſt cavities. Theſe eggs in time produce Worms, which afterwards turn to Nymphs, and then to Flies: and this buſineſs conſtantly proceeds according to the immutable decrees of providence, in one uniform circle of production, without the leaſt variation in time or place, unleſs it be when the Flies cannot find cheeſe to receive their eggs, for then they look out for ſome other kind of food, as much reſembling cheeſe as poſſible, in its nature and qualities. Thus has this ſpecies of little creatures been kept up from the time of Adam to our days, thro' a ſucceſſion of many thouſand generations.

After having made the obſervations already related, I thought it worth my while to examine the skin which is ſhed by this inſect, on its appearing abroad in the Fly-ſtate; and upon inſpection, I found that it contained a very delicate tranſparent membrane thrown off at the ſame time. In this membrane I could diſcern a great many of the pulmonary tubes which had likewiſe peeled off from the body; and what was ſtill more ſurpriſing, the ſnout of the Worm, with its teeth or claws, remained entirely with it. Theſe unſeemly organs, with which they heretofore uſed to crumble and take in their unſavoury food, and to run about and burrow in their putrified habitations, are no longer neceſſary in the Fly-ſtate. Theſe creatures have, inſtead of them, a trunk or proboſcis, by means of which they ſuck up the ſweeteſt juices, and a pair of ſwift and beautiful wings, wherewith they ramble at pleaſure thro' the untainted air, and raiſe themſelves far out of the reach of ſtench and putrefaction.

I heartily wiſh you, illuſtrious friend, a ſimilar change and reſurrection, of which that now we have been conſidering, ſeems to be an earneſt; for I am firmly perſuaded, that by treading courageouſly to the end of this mortal life, in the footſteps of our Divine Maſter, we ſhall then change it for a better; and lay down this corrupt body, to which we are now confined, in order to aſſume a far more perfect one. God, the giver of all good things, grant us this neceſſary perſeverance, thro' the infinite merits of his only Son, our Lord and Saviour. Amen.

The End of the ſurpriſing hiſtory of the Acarus, or Mite, and the Fly produced from it.

The hiſtory of the Worms found in the tubercles and ſwellings of the leaves of the Willow.

PART I.

AS in enumerating the Inſects which belong to my fourth order of changes, I have aſſigned there the place for all thoſe Nymphs which are found encloſed in fruits, tubercles of plants, trees, and their leaves; I ſhall now propoſe ſome of thoſe Nymphs, by way of a particular example. In treating of the Worms found in the tubercles of Willow leaves, I ſhall deſcribe the Tubercle itſelf, the Egg, the Worm, its Web, the Nymph, and the Fly.

The warts or tubercles of the leaves of the Willow, Tab. XLIV. Fig. I. are ſo obvious to the view, that there would be no neceſſity to deſcribe them, provided each of us had the ſame ardent deſire, and equal curioſity. But as all men are not delighted with the ſame thing, the moſt common objects in nature ſometimes remain unknown, and affect the ignorant with a rapturous admiration. For this reaſon, I ſhall briefly, in this place, explain the conſtruction, figure, colour, ſituation, bigneſs, tenderneſs, hardneſs, and ſmallneſs of theſe tubercles.

That the conſtruction of the ſeveral ſwellings that are obſerved in the leaves of the Willow trees may be diſtinctly known, we muſt firſt conſider particularly the leaf itſelf on which they are found. The leaf of the common Willow conſiſts of three coats; the internal as well as external, are very thin, and are ſet with light hairs, or a kind of down; but the middle coat is nervous and fleſhy, if I may be allowed the expreſſion; ſince the nerves, or rather the veſſels which convey the nutritious juice to the leaf, are placed in that part. Theſe veſſels are, indeed, extremely numerous, and are divided into ſo many ſcarce viſible branches in this coat, that they may be properly called the parenchyma, and compared to the fleſhy ſubſtances in the viſcera of animals: this may be ſeen moſt diſtinctly in thoſe kinds the leaves of which are thick and ſpungy.

The outward coat, or external ſide of the leaf, I call that part wherein the nerves or ribs are prominent, Tab. XLIV. Fig. I. *a.* beyond the reſt of the ſurface: the external or outer coat, and the inner coat, or inward ſide, I call that part of the leaf which exhibits theſe nerves, not ſo diſtinctly conſpicuous *b b.* Between theſe two coats the tubercles of the leaves, whereof we are treating, are ſituated, and they are nothing elſe but the dilatation, or more remarkable, yet irregular excreſcences of the inmoſt and nervous part of the Willow leaf. Theſe tubercles, therefore, are properly compoſed of a collection of the very fine veſſels of the leaf, which, concreting together into a maſs, form an extuberant little knot; to which the two coats of each ſide are ſo ſtrongly joined, that they cannot, but with difficulty, be ſeparated; nay even, theſe too are ſo much dilated by force of the tubercle, as to loſe their down or hairs in that part.

The external figure of theſe verrucæ, or tubercles, is very irregular: they are ſometimes roundiſh or oval *c*, ſometimes oblong *d*, and they are wrinkled *e*, ſmooth, and of many other ſurfaces and forms. Their internal ſtructure conſiſts, as it were, of little grains, reſembling broken free-ſtone of a large grain, and is filled with ſmall chinks and corners, viſible only with a microſcope.* The outward ſurface is of a (ſometimes faint, and ſometimes full) green colour, and is variegated with purple, red and yellow, all together or ſeverally: there are likewiſe ſome ruſty, ſmall and blackiſh ſpots obſerved in ſome of them, which are like marks of vermiculation *f*. Theſe tubercles are within of a full green, and at the ſame time ſomewhat yellowiſh here and there: this yellowneſs probably ariſes from hence, that the Worm hath conſumed the inward ſubſtance about thoſe places.

Theſe warts occupy various parts of the leaf: they are ſometimes found *g* in the middle region, adjacent to the nerve; they lie *h* ſometimes near the extremity of the leaf; ſometimes they are on the nerve *i*; ſometimes more ſwollen or depreſſed, and again are ſituated at a greater or leſs diſtance from each other; and therefore nothing certain or regular can be determined, in this reſpect, about them. They are conſtantly extuberant beyond the ſurface of the two coats of the leaf: but in that ſide of the leaf where the nerves run, they commonly project more than in the inward ſide; tho' I have found ſome which roſe to an equal height on each ſide *k*. I have likewiſe ſeen ſome which occupied the footſtalk of the leaf *l*; but theſe were fewer.

There is great difference between the warts, in regard to bigneſs and ſmallneſs, and alſo with reſpect to their greater or leſs number. In ſome leaves there are ſeen only one or two, in others ten or twelve. They differ alſo greatly in ſize. The reaſon of which is, that ſome of them are riper than others; or they are older, or have begun to increaſe afreſh. I ſhall hereafter treat of this matter in the hiſtory of the egg, and ſhall then likewiſe deſcribe their hardneſs and tenderneſs.

When I opened ſome of thoſe warts of theſe leaves, on the 14th of June, I met with quite different things therein. In ſome, which were ſhut very cloſe, I found a Vermicle, or Worm, like the Caterpillar of the Bindweed, together with its excrements, and a caſt ſkin near it. In another, which opened outwardly, with a round or orbicular orifice, I found another Caterpillar, of the ſame ſhape with the former, but conſiderably larger. In others that were not perforated, and ſtill contained their Caterpillar of the ſame kind within, I obſerved this was ſuffocated, or had been killed, by ſome other Worms, which likewiſe lodge themſelves in the warts. I obſerved that the rain had fallen into ſome others, that had holes, and were deſtitute of an inhabitant. In others again I found other inſects, which had caſt their eggs there. Nay, I ſometimes found the little caverns of theſe tubercles occupied by ſmall Spiders, which had ſhut up the orifice with one of their webs. I ſhall treat of all theſe things more particularly hereafter.

Theſe differences, obſervable about one and the ſame kind of tubercle, may, no doubt, lead ignorant perſons into error. Indeed, I am firmly perſuaded, that all who apply themſelves to experiments will be deceived, unleſs they thoroughly inveſtigate them, and endeavour to find out their firſt principles. Wherefore, as I had at different times obſerved what is before related, I have again, at length, examined theſe excreſcences with all the care poſſible. And thus I have, at length, diſcovered the real eggs out of which thoſe firſt Caterpillars, which I ſaid I found in the tubercles, are produced. At the ſame time alſo, I diſcovered the reaſons why other inſects alſo go into theſe warts.

On the ſaid 14th of June, I opened a great number of tubercles, of all kinds and figures: in the ſmalleſt of them I found real and perfect eggs, ſo circumſtanced in every reſpect, as if they had been laid there by the inſect. The leaf of the willow, in which I found ſuch an egg, had but very lately budded, and was ſtill tender, though it had obtained its full ſize and form. I found in this leaf the rudiments of ſeven ſuch excreſcences, which I repreſent in each ſide of it, Tab. XLIV. Fig. I. *m*. Some of theſe were a little larger, others ſmaller; but the minuteſt of them were ſo ſmall, that they could be obſerved only by reaſon of the ſmall change which was obſerved in the colour of the leaf. The largeſt of the tubercles, which began to ſwell a little, were of a yellowiſh green colour; but the ſmalleſt of all, which did not yet project beyond the ſurface of the coats of the leaf, was diſtinguiſhed from the leaf itſelf only by a paler yellow colour.

We muſt here obſerve, that the egg was alſo ſmaller in the ſmalleſt than in the largeſt excreſcences; in which I conſtantly found it much larger, and more advanced and forward. This egg was of an oblong figure, Fig. II. *n*, without any rings, having one end thicker, the other more acute. It appeared tinged with a watery colour, and had an extended ſmooth ſurface. Theſe eggs lay looſe and diſengaged in theſe tender tubercles. There was no particular little cell; but they were every where equally ſurrounded with the inner ſubſtance of the tubercle. But when the wart afterwards becomes larger and harder, and by degrees loſes its ſtiffneſs and tenderneſs by accretion, then it is obſerved, that it inſenſibly opens on the inſide; and in proceſs of time is divided, as it were, into two diſtinct parts: in one of which only an egg is placed, Fig. I. *o*, and is gradually increaſed and augmented.

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* Theſe tubercles and warts, like galls, and the tufts on the dog-roſe, all ariſe from the punctures of inſects; and as there are many kinds of theſe inſects, it is not ſtrange that the tubercles are of various forms. They are all produced by wounds, at which the eggs of the parent-animal are introduced; and the young Worm conſtantly appears within them. Theſe Worms are, in general, very weak and defenceleſs; and this ſeems a proviſion of nature to hide them from their enemies.

About that time one may very diſtinctly ſee, that the egg is no where fixed or annexed to any thing, nor has any veſſels, filaments, fibres, or any other ties, by the help of which it may cohere with the wart, and receive nouriſhment from it. Indeed, it never has any certain place in the tubercle; for it is ſometimes fixed in this, ſometimes in that ſide: it is ſometimes in the middle: it is ſometimes at a greater or leſs diſtance from the chink, which is naturally obſerved in the body of the tubercle. There are as yet no excrements found in the wart; but all things appear pure and clean.

It is very certain, that this egg is then in a ſtate of nouriſhing; for one may plainly ſee, that it is conſiderably increaſed, from time to time, and augmented. But the moſt obvious ſigns of this are obſerved chiefly in thoſe Worms which are a little older; for in ſuch the fore part of the egg is conſiderably ſwollen, ſo that even the head and two eyes of the Worm or Caterpillar, encloſed in it, are gradually ſeen through its integuments, and are obſerved, Tab. XLIV. Fig. II. *p*, to grow continually blacker.

If therefore it be aſked, how this egg is nouriſhed? I anſwer, it may conveniently have all neceſſary food from the effluvia and tranſmitting liquids, which perſpire into the cavity of the divided and broken excreſcence, and likewiſe may eaſily penetrate the coat whereby the egg is inveſted; ſo that they may be ſucked in, and ſwallowed by the Worm that lies within. All membranes ſerve to illuſtrate what I have here aſſerted; for theſe being put into a damp place, are likewiſe affected by the moiſture: but when they are ſuſpended wet in the air, or are expanded, again they exhale, by a contrary action, all the moiſt humours which they contain. Nay, it is plainly ſeen that gum tragacanth, though tied up in a membrane, is notwithſtanding conſiderably ſwollen, when put in a moiſt place. But here it deſerves particular notice, how powerfully ſalt of tartar attracts water to it. In the roots of trees and herbs, wherein open pores are not yet demonſtrated, no other mode of nutrition can indeed obtain or prevail. However this matter be, I think the juice, perſpiring from the ſubſtance of the warts, feeds the Worm that is thus contained within it.

Now, as an egg is nothing elſe but a Nymph encloſed in the pellicle, not yet having the firmneſs and ſtrength neceſſary to break open this coat with which it is ſurrounded, one may eaſily comprehend how the Worm, ſtill contained in the ſhell of its egg, may ſuck the nutritious juice which penetrates into the cavity of the egg. And indeed this obſervation, by which it is evident that the egg is nouriſhed, and becomes bigger, whilſt it is and remains an egg, moſt ſtrongly proves, that the egg is really the inſect itſelf; nor is there any other difference between this and that, only in reſpect of the inveſting coat, which prevents our ſeeing the contained inſect; though, in ſome caſes, one may diſtinctly enough obſerve it tranſparently through the ſkin of the egg. The egg, of which we treat in this place, is, in this reſpect, different from thoſe of many other inſects, becauſe the latter never increaſe, but for ſome time only cover the contained little inſects; juſt as the membranes of the Nymphs ſurround or environ the encloſed inſects for a time.

When this little creature afterwards has broken out of its egg, it has the form of a thin and ſmall Caterpillar, and is twice as long as the egg wherein it had been hid a little before. It is then always found within the tubercle, that the ſkin caſt off by the little inſect lies near to it. This little Caterpillar is at this time ſo ſmall, that, if it were delineated according to its natural ſize, it would ſcarce be as big as a point: wherefore I repreſent, Tab. XLIV. Fig. I. *q*, it rather at its full maturity, as it appears when it hath bored its way through the tubercle, and crept out through the hole *r* it made.

This little Caterpillar properly belongs to what are called the Bind-weed kind. If you view it with a microſcope, you will ſee it compoſed of fifteen annular inciſions, which conſtitute the head, thorax, abdomen, and tail. The head is of a raven-black colour, and exhibits, Fig. III. *s*, the eyes placed on each ſide. In the fore part, in the lower region of the head, are ſeen two hard horny or bony jaws; the extremities of which are divided into many ſmall ſharp-pointed teeth. With theſe the inſect, when provoked, is not afraid to bite even at a ſteel-needle. Theſe teeth are of a browniſh red colour, and tranſparent ſubſtance. The ſix firſt legs, *t t*, each of which conſiſted of five joints and one claw, were articulated with the three foremoſt rings of the thorax. The two rings immediately following had no legs affixed to them. But twelve other legs, Tab. XLIV. Fig. III. *u*, adhered to the lower part of the ſix rings of the body. Finally, the tail was alſo furniſhed *x* with two: ſo that this inſect has in all twenty legs. In the poſterior part of the head, and in the neck, as alſo about its tail, there are ſome black ſpots. This Caterpillar, like the Coſſus, or Worm of the Beetle, had a wrinkled ſkin, here and there ſet with hairs. It twiſted and gathered together the poſterior part of its body, like the Bindweed Caterpillar. It did not frequently make uſe of its middle, or laſt feet, except when it endeavoured to wind and twiſt the poſterior part of its body about the extremities of leaves; for then it faſtened itſelf in the place with its feet, making no uſe of its fore legs at the ſame time. When it walks, it uſes only the fore legs, and then draws after them the hinder part of its body. This is likewiſe the caſe in regard to the Caterpillars, before mentioned, which have many legs; and which likewiſe change into Butterflies ſo conſtantly, that I have hitherto obſerved no example to the contrary. The points of reſpiration were ſeen to open in the ſurface of the body, and the pulmonary tubes were tranſparent through the ſkin. In the hinder part of the body, the heart ſhewed itſelf alſo, beating.

While theſe little Caterpillars are ſmall, they are of a colour mixed of a yellowiſh white and pellucid green, which by degrees improves and grows ſtronger. Even while they are, as it were, ſtill in their cradles, a narrow line of a deep green colour, which denotes the aliment contained in the ſtomach, is ſeen through their ſkin; and this becomes of a more and more duſky green, the more the Caterpillar approaches to maturity; and the Caterpillar itſelf then alſo gets a much greener colour all over, only that it continues of a yellowiſh white about the belly. Theſe little creatures ſeveral times change the ſkin within theſe warts, and grow whitiſh for a time, on caſting it.

The inner ſubſtance of the wart is their food, which they immediately begin to eat, as ſoon as they come out of their eggs. About that time their excrements alſo are found in the tubercles; and there is the greater quantity of them accumulated, the more the Caterpillar is grown. I have ſometimes found ſo great a quantity of theſe excrements in the tubercles, that it was three times bigger than the body of the inſect. This principally proceeds from rain, which ſwells theſe feces, and ſometimes kills the little Caterpillar. This moſt commonly happens, when it has already bitten through and perforated the coats of its wart, or tubercle. Theſe habitations are commonly pierced through by the Caterpillars, when theſe inſects are arrived to their full ſize; for then they always eat a hole through their tubercle, and then thruſt the hinder parts of their body through the hole, ſo that they may caſt out their excrements, Tab. XLIV. Fig. I. *y*. The Caterpillars behave in this manner chiefly in rainy weather; for then their excrements ſwell vaſtly by the force of the wet, and would occupy too large a ſpace, being otherwiſe not bigger than ſmall grains of ſand.

In proceſs of time the whole ſubſtance of the wart is ſo cleanly eaten out by the Caterpillar, that abſolutely nothing remains of it but the two outmoſt coats of the leaf. After this the creature ceaſes to eat, though it ſometimes alſo abſtains ſooner. It is indeed very worthy of conſideration, that the Worm in this excreſcence finds its aliment in ſuch plenty, that it is never in want. On June 29, I obſerved that many of theſe Caterpillars had crept out of the mouths or orifices of the verrucles, or little warts; nor could I, notwithſtanding, find any of them either on the tree, or under it on the ground. In another tubercle, which I then opened, I found a dead Caterpillar. In another, the little creature had been entirely conſumed, its remains reſembling only a thin ſkin; and near it lay a Worm without legs, which had probably conſumed the entrails of the Caterpillar, and afterwards had crept out of the tubercle, in order to undergo its proper change. As I had unluckily given this Worm a little wound, I could not further proſecute its changes. I ſhall not preſume to affirm, as a certainty, that the viſcera of the dead Worm were conſumed, or had been pierced, by this creature.

In order to inveſtigate further what is done by theſe little Worms, I brought ſome leaves and little branches of Willow-trees into my chamber, and there put them in moiſt ſand. But ſo it happened, that the Worms of theſe, having quitted their tubercles, got into the ſand out of my ſight. As I imagined it was the want of food that made them leave their abode ſo quickly, I put ſome leaves and entire warts of them upon the ſand: nay, I likewiſe offered ſome of them a maſs or lump, prepared of ſome bruiſed tubercles, in order to invite them to eat; but all was to no purpoſe. I therefore finally encloſed ſome of them in a dry box, into which I had before put ſome rotten wood, that I might ſee whether they would make their webs there. All theſe died likewiſe, pining away, ſome ſooner, ſome later: wherefore I at length learned, that they could not live naked or uncovered in the air.

On the 5th of July I obſerved, that ſome of theſe little Worms had dug into the ſand, and there began to weave webs; and this was the firſt opportunity I had of diſcovering any approach toward their change. For, when I diligently examined the ſand on the inſide, I found a great number of them in it, ſome of which lay much deeper than others. And thus I at length diſcovered, that theſe little creatures, after they have eaten ſufficiently, quit the Willow-leaves, and fall; and then dig into the earth, in order to weave their webs there, and ſuffer other changes.

Out of this ſand likewiſe I took ſome perfect webs. They were of an oval figure, Tab. XLIV. Fig. IV. *a*; ſo that if they were expoſed on the ſurface of the earth, the moiſture or rain could not do them great harm. I have likewiſe obſerved ſome Spiders woven up in webs. Theſe webs were of a bright purple, approaching to ſcarlet. I afterwards opened one of theſe webs, woven by the inſects; but found that the Caterpillar, in the inſide, was not yet changed. On the 6th of July I cut open ſuch another web; and in this alſo there the inſect ſtill lived, in full vigour. In the third web which I opened, I found the creature juſt on the point of ſuffering its change.

Its green colour began by degrees to diſappear. The body became a faint yellow, and decreaſed very much in bulk, becoming at the ſame time clear and perſpicuous; as is likewiſe the caſe in Silkworms. The little line on the back, produced by the contents of the ſtomach, became likewiſe obliterated by degrees; ſince the Worm had now cleared its inteſtines of all their groſs contents, afterwards lying in its web without any remarkable motion.

July 13, I found ſome dead in their webs; but others had by that time aſſumed the habit of real Nymphs. Therefore it is evident, that theſe inſects ſtrictly belong to the firſt mode of the third order of natural changes; though I ſhall not here refer them to it, becauſe they weave their webs, and are changed in a very obſcure manner under the earth.

Some days after, that is July 18, I obſerved many little black Flies iſſuing, Tab. XLIV. Fig. IV. *b*, out of thoſe webs which I had taken out of the ſand, and put into a dry box. This little Fly, being viewed with a microſcope, ſhews itſelf divided as uſual into a head, thorax, and belly. Out of the fore part of the head ariſe two black horns, Fig. V. *c*. Theſe are placed before the eyes. The thorax is elegantly divided, and ſhews four membranaceous wings fixed to its ſcapulæ, whereof the lower pair are covered by the upper, and all together cover the body. The upper wings are provided with many pulmonary tubes, paſſing through them, and near their extremities are marked *d d* with two blackiſh ſpots. Six legs adhere to the loweſt region of the thorax, *e e*, that are divided by joints and two claws: they are of a colour approaching to black. The abdomen alſo is black, and is divided into rings. Some of theſe Flies alſo had a tail, others not.

The males I found had tails, but the females none. If the laſt rings of the females abdomens were preſſed out, Fig. VI. *f f*, towards the hinder extremity, a ſharp-pointed part was forced from thence; which being carefully examined with a microſcope, exhibited an inſtrument like a ſaw, *g* ſituated *hh* between two pointed horny or bony little parts, and conſequently fit for piercing the coats of leaves; as I ſhall relate hereafter. On viewing the under part of the female's body, I obſerved that it grew white about the breaſt, but that the legs were ruddy there.

But when I afterwards opened the female's abdomen, I found perfect eggs there, exactly like thoſe, which I before deſcribed to be found in the tubercles of the leaves: ſo that doubtleſs, they are eggs of this Fly, which are found in the tubercles. This Fly is of the ſame diſpoſition with thoſe which proceed from conſumed Chryſallides. Nor did Flies break out of thoſe webs only, which I had put into the box: they likewiſe iſſued out of the webs, which were yet buried in the moiſt ſand. Hence I ſaw ſome ſuch little Flies lying dead in the ſand, and others that had grown faint and weak with the moiſture.

In ſome other webs I found living Flies which iſſued from thence ſo quickly, that I could not catch them. I likewiſe opened ſome males of this kind, and therein found the male organs of generation: however, I cannot now ſay much of them; becauſe I did not commit my obſervations thereon to writing. Theſe little inſects are changed in a double manner: for when it happens, that their Worms, at the end of the year, creep into the ground, and there form webs; Flies do not proceed from them before the ſpring of the following year.

I cut open alſo the webs that were forſaken by theſe Flies; which indeed, they break in a very ſingular manner: they make a round hole *i*, Tab. XLIV. Fig. IV. in each, like that in a barrel. In thoſe webs I found a ſkin, which the little creature caſt off, when it became a Nymph, and alſo a tender ſkin, which the Nymph, on being changed into a Fly, had afterwards caſt.

After the creatures forſake the tubercles; theſe latter grow dry entirely, and in ſome days become contracted together. But as my curioſity had proceeded ſo far as to keep all theſe little inſects, as they are circumſtanced in all their changes; hence I learned, that theſe tubercles could not be otherwiſe kept in the Willow leaves, than by filling them with a ſufficient quantity of dry ſand, and then leaving them to themſelves, until they grow dry: after this, the ſand may again be eaſily taken out of their cavity. Let this ſhort deſcription of this great and unheard-of natural miracle ſuffice; in which the wiſdom and providence of God are clearer than the meridian ſun.

In what manner the eggs of theſe little creatures come into the leaves of the Willow-tree.

MANY who call themſelves ſearchers into nature's ſecrets, agree, that all obſcurer modes of generation muſt be attributed to putrefaction as their cauſe, which is the effect of moiſture joined with heat. And this opinion extends even to ſtones; for they obſerve, that ſome inſects iſſue from them. It is however very remarkable, that they cannot prove or illuſtrate that aſſertion by any one ſolid argument, or fair experiment. They rely only on their own erroneous opinion, occaſioned by an univerſally prevailing error. I except only Dr. Francis Redi, who has pointed out a very different and much better way: for he, having firſt, by irrefragible arguments and reaſonings, deſtroyed the ſyſtem of generation by putrefaction; yet not improbably infers, that theſe little inſects, which are found in leaves, fruits, and the like ſubſtances, are generated there from the very ſoul and natural vigour of the vegetable which produces the fruits and plants. I ſay, the opinion of this gentleman is not altogether

together improbable; for the experiments that may be made concerning the matter, are involved in ſo many difficulties, obſcured by ſuch thick darkneſs, and are ſo inextricable, that one may be eaſily induced to think theſe little creatures are really generated from the plants themſelves.

This induced me to inveſtigate, with much labour and difficulty, the origin of the Worm in the tubercles of Willow-trees. Dr. Redi ſays, he could never ſee that the Worm itſelf is changed; and, I confeſs, I ſhould eaſily have concurred in opinion with this gentleman, if I had not, though he did not ſucceed, diſcovered the abſolute change of this Worm into a Fly, and had not obſerved the eggs in the Fly's body to be like thoſe which are found in the tubercles. I cannot agree with this very learned author, that the Worm has only ſix feet, as it is repreſented by him; for I find, on the contrary, that it is provided with twenty.

Theſe are errors into which each of us may eaſily fall. And, indeed, I have not advanced what I have hitherto ſaid with deſign to confute a gentleman who is my friend; for I think none ought to be cenſured with the rod of correction, but thoſe petulant perſons, who, ſwollen with vain-glory, bark like Dogs at all writings whatſoever, and ſeek laurels for themſelves by defaming others, which Bartholinus endeavours to do on every occaſion; and hence even his theſes are debaſed by railings. Indeed, all our writings out to be directed to find out the truth with our beſt ſtrength: I ſay, the truth, to which we all ought to adhere, whether it favours or oppoſes our own opinions, ſince there is nothing really amiable but its beauty only. Therefore, though the opinion has an air of probability, I ſhall not agree with the celebrated Redi, that any creatures are ever produced from vegetables, in the ſame manner that leaves and fruits iſſue therefrom.

I know indeed ſome learned men, and ſome of very eminent rank alſo have been brought into this opinion. But I know too, that it will never be proved by experiments, however fair it may appear. For I am really obliged to confeſs, that opinion ſeems to be ſo conſonant to truth, that, unleſs theſe Worms had increaſed into winged and ſtinged animals before my face, I could ſcarce have ſaid any thing to the contrary. Finally, in order to give my own opinion, with which I obſerve the very excellent phyſician Dr. Francis Redi formerly concurred, I think, indeed, that all thoſe tubercles of plants, leaves, fruits, and excreſcences in the which inſects are found, are of no other uſe, nor do they grow for any other end or purpoſe, but to give a ſafe habitation to the animals in them, in order to preſerve them, and likewiſe to ſerve for food *. Indeed, extreme neceſſity, in this caſe, required ſuch proviſion; for many of theſe Vermicles have no feet, by the help of which they might move about, and get food for themſelves. This is particularly remarkable with reſpect to the Worms of Bees and Ants, which have no feet; ſince the former are, for this reaſon, very carefully nouriſhed by the Bees themſelves; and the latter are, for that reaſon, continually removed into different places, in which they can get food without aſſiſtance. Tho' the Worms which we have above deſcribed have feet, they make moſt uſe of them when they ſeek for the habitation, wherein they weave their webs; but they by no means ſerve them to find out their food. Therefore, both in the conſtitution of the parts, and in the food, which the Worms found in the tubercles, there ſeem to appear reaſons of great moment, why theſe tubercles are produced. Theſe are perhaps, however, mere conjectures; while Nature herſelf never intended, in her works, any thing to verify them. God ſhews himſelf every where equally adorable and immenſe.

I think theſe Worms, which are found yearly within the ſame kind of tubercles, and are peculiar and natural to them, are produced only from eggs of inſects of the ſame nature, or congenial with them; that is, ſuch inſects as depoſit their eggs on the plants, leaves, or fruit, and convey them thither from without. This is indeed evident from what I have before obſerved, with reſpect to the eggs that lie in the tubercles of Willows, and thoſe that are found in the bodies of Flies produced from thence: for theſe two kind of eggs do not in the leaſt differ from each other.

Now, then nothing further remains but to explain the method whereby theſe eggs are conveyed into the leaves of the Willows. Nor do I ſee much difficulty in this matter: for, ſince the mother Fly is armed with one or two weapons, proper to pierce ſuch ſubſtances, and with another inſtrument, which is fitted for directing and guiding the eggs iſſuing out of her body; ſhe may very eaſily pierce the tender leaves, when recently ſpringing out, and may caſt her ſmall, and almoſt inviſible eggs, into the little holes that are thus made: that this really happens, and in this manner, is the more manifeſt; becauſe, in the new leaves that have juſt appeared, the little egg is found every where looſe and diſengaged; and only a part of it is ſituated between or under the coat of the leaf: nay, I have ſometimes thought I ſaw the little holes, thro' which the eggs were conveyed into the ſubſtance of the leaf.

I own, this hiſtory would at length be completely perfect, if I could ſee all I have advanced, as my opinion, which, I think, I ſhall hereafter be able to do. But though I have not hitherto done that, the experiments which I have now propoſed, to confirm my opinion, ſeem to me ſo ſtrong, that no body can deſire more convincing. I willingly confeſs, I have not accurately and diſtinctly ſeen the perforation of the leaf in all its circumſtances: but I ſhould think, that it is not poſſible for it to come within the

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* Reaumer, indefatigable in his ſearches into the inſect-world, has given us an account of a peculiar race of creatures, which he calls Mineurs des Feuilles, miners of leaves. Theſe burrow between the outer rind and ſubſtance of the leaf, feeding as they go, and leave a tract of white behind them, ſo that the leaf ſeems variegated.

cognizance of the eye-ſight. For, who can ſee the wound in his ſkin, made by the ſtroke of a Gnat or Flea, immediately after it is inflicted? Surely no one. What one ſees in the ſkin, is nothing elſe but a change of colour: and this is likewiſe obſerved in the leaf of Willows; that is, the place through which the egg is conveyed and joined to the leaf, is diſtinguiſhable in no other manner but by a ſmall diſcolouring. To which we may add, that the little wound, given to the ſucculent leaf, by ſo ſmall a creature, eaſily cloſes up again, and is ſtopped and filled up by the impelled humours.

It will be aſked, why are tubercles produced in the Willow leaves, for the benefit of thoſe eggs conveyed into them? And how are thoſe rare and admirable excreſcences generated in other plants and trees? I confeſs this queſtion is very difficult to explain. Nor do I know what other anſwer to make to it, but that the firſt ſtroke, which the inſect mother gave the plant, fruit or leaf, into which it endeavours to put the egg, is the real cauſe of the tubercles produced afterwards, whatever form or figure it may aſſume. Do not we thus on Pompions, and other fruits, and even on trees, by the help of a knife, or bodkin, cut letters and characters; the veſtiges whereof inſenſibly ſwelling with the humours, raiſe themſelves up conſiderably beyond the common ſurface?

I do not think this is done by chance, but by a previous deſign of nature, which has ordered, that this generation of inſects, and the tubercles which ſerve for nouriſhing them, ſhould be produced in this, and in no other order. Therefore alſo, the generation of theſe inſects is plainly regular, and is not ſubject to any fortuitous change. The great Harvey, in his book of generation, fully demonſtrates, how much the ſtrokes, ſtruck with one and the ſame external inſtrument, differ from one another; when he ſays, from experience, ‘That the fleſh itſelf diſtinguiſhes the ‘poiſoned ſtroke of a ſting, from that which is ‘not poiſoned:’ and further proceeds: ‘And ‘therefore, from the poiſoned wound, it is ‘ſtrained and condenſed, and therefrom ariſe ‘tumours and inflammations. I once, ſays he, ‘for the ſake of the experiment, pricked my ‘hand with a needle, and immediately after, in ‘another place, with the poiſonous tooth of an ‘African Spider; I could not diſcover any difference between theſe two little wounds in feeling; but there was a great difference ſhewn in ‘the ſkin; for when the poiſoned puncture had ‘been made, it ſuddenly ſwelled.’ Who can preſume to deny, that plants have this kind of ſenſe? I ſhould indeed think they would exhibit manifeſt ſigns of ſenſe, if they had muſcles; the want of which ſeems to be only the cauſe, that prevents their being able to ſhew us their faculty of ſenſation. This is evident in the celebrated ſenſitive plant; which, in my opinion, has a certain ſpecies of muſcles, by the help of which, it extends and contracts its little boughs, almoſt like arms.

As to the different figures of theſe tubercles, which are never found on plants, but they are pregnant with little inſects, to be nouriſhed within them; I think they are cauſed principally by the variety of the ſtroke, whereby thoſe creatures perforate plants, and fix, and, as it were, inoculate their eggs in them: this may be likewiſe ſeen in all inoculations. For the ſame reaſon, the Flea forms with its ſtroke in our ſkin, a ſwelling altogether different from that of the Bug: and the latter differs alſo from that of the Bee. All theſe things are far from being ſubject to chance; they proceed in a certain order, and they are obſerved to be always ſimilar: except when the plants, or bodies of animals, have different figures; as the celebrated Redi hath accurately and clearly obſerved in regard to the bites of ſerpents.

I have often ſeen the legs of inſects ſo ſtrongly impreſſed upon the tender branches of trees, that they could not be taken off without injuring them. But, principally, the Dutch phalæna, which proceeds from the Worm, found chiefly in the bark of Willow-trees, and of the Maple, which it corrodes in ſome meaſure, and impreſſes its eggs outwardly on the bark: hence it follows, that the Worms produced therefrom, afterwards make a paſſage for themſelves inwardly towards the wood. Nay, if you pull theſe Worms out of the tree, they firſt weave and cover themſelves with a web; and then having afterwards broken it, they pierce the wood with their teeth; and, in ſo doing, reſt upon the web on their backſide, in order to get ſufficient power and ſtrength to penetrate.

This winter, I obſerved in turnips many warts and tubercles of various ſizes, in which lay ſo many Worms without feet, but furniſhed with eyes and hard teeth. In the ſmalleſt of the warts or tubercles, I found a little egg; and in the larger ſort, a tender and ſoft Worm. In regard to theſe Worms without feet, that are found in tubercles on plants; it is worthy of notice, that they can by no means be kept alive, when they are drawn out of the cells, which they have formed for themſelves, in proportion to the bulk of their body within the excreſcences, and in which they are nouriſhed. The cavity, wherein that wonderful Worm is lodged, which lives encloſed in the young buds of Willow trees, as in a roſe, which will be afterwards particularly deſcribed, exactly anſwers to the bulk of its body. The Worm that lies in Turnips, has a cavity ſomewhat larger than its body. I have obſerved alſo, that thoſe little cells, which the Worms, without feet, form themſelves with wonderful art in dry timber, are nicely fitted to their bodies; and they can therefore, with ſufficient quickneſs, move through theſe cavities. They perform this motion by drawing in, and fixing their hinder parts to the wood, and ſtretching out their forepart: and thus they move forward with great ſwiftneſs in theſe burrows.

When theſe little inſects are deprived of their cells or caverns, and the nouriſhment they have there ready; they cannot move any more; they ſtiffen with the heat and dryneſs of the air, and periſh by innumerable other ways. Many feetleſs inſects alſo, that live under the earth, and in the water, are nouriſhed and ſuſtained in the ſame manner. For thoſe that have no feet, and live in the water, change place by the help of their tails and certain appendages, which ſerve them inſtead of oars. But the Worms that live under the earth, advance forward almoſt in the ſame manner as the Worms of Beetles, and creep in this manner between the cracks and fiſſures of the mould. What happens to the feetleſs vermicles of Flies, Ants and Bees, may be ſeen in the hiſtories I have already given of theſe inſects. As to the Caterpillars, and other of the many-leged inſects; the matter is clear, and without all difficulty. Nay, it is no way repugnant to my propoſition, that ſome inſects are obſerved to iſſue, after ſome years, out of rotten wood: for, we know, that theſe inſects ariſe there alſo from Worms, and that theſe draw their origin from eggs; the females regularly betaking themſelves yearly to ſuch wood, and caſting their eggs into it. It is often neceſſary, that ſuch Worms ſhould receive increaſe for ſome years before they arrive at their time of change; as is manifeſt in the Coſſus, and in that Worm alſo, from which the Holland Cantharis, commonly called the Golden Beetle, is produced. The ſame thing likewiſe holds in the Aquatic Worms, that live in the tubular cells, as I have already remarked in the hiſtory of the Ephemerus.

We muſt further obſerve, that many creatures that are ſaid to want feet, are really provided therewith. Thus the Earth-worms indeed have many feet, but they are conſtituted in another manner than feet commonly are. I have clearly ſeen the ſame thing in ſerpents: theſe I have indeed obſerved, have five ſorts of feet. Some of them have a thorny or ſpinous excreſcence in the middle of their body, with two heads, almoſt like the military Caltrops, and contain in the middle a little bone, which is articulated in the os pubis, and covered with a ſkin; by the help of this, they can move quickly over the rough ſurface of the earth; and in cracks of rocks, I have ſeen others again provided with two ſuch machines for their greater ſwiftneſs. Two feet of a certain third ſpecies were preſented to me, which being compoſed of diſtinct articulated bones, likewiſe carry claws on their extremities, which may be drawn out of them, like the hollow claws of hogs feet. I myſelf have examined a fourth ſpecies, which had four articulated, but very ſmall feet; the foremoſt of which conſiſted of three joints, and two toes; the tops of which were armed with claws: another ſhorter joint alſo, or, as it were, ſmall thumb, armed with a claw, projected alſo out of their inſide. The hindfeet alſo were made in the ſame manner, only that they had one toe more than the forefeet. Laſtly, D. Frederick Ruyſch, profeſſor of ſurgery in Amſterdam, made me a preſent of a fifth ſpecies, furniſhed with very tender feet; each of which conſiſt of three joints, but they are not diſtinctly viſible; becauſe they are covered even to the extremities with the ſcales: at the extremity of them, is ſeen only a ſimple claw, without any diviſion into toes. Therefore, that little ſerpent ſeems capable of making uſe of thoſe feet, only on certain conditions or occaſions; ſince, on account of their great tenderneſs, they are not able to ſupport the body, tho' they may often contribute to move it with the greater ſpeed. Behold, how admirable God ſhews himſelf in all his works! the ſmalleſt of which moſt clearly expoſe to view his Magnificence, Majeſty, and infinite Wiſdom.

Of other inſects found in the tubercles of Willows; and how they come there.

IN the preceding pages I have obſerved, that when I opened the tubercles of the Willow tree, I found various other inſects beſides the Caterpillars there mentioned; and this may impoſe upon, or deceive, the unexperienced, who are accuſtomed to make experiments only ſlightly: ſince it may be poſſible, that one animal ſhould be taken for another, and wrong concluſions drawn from thence. For this reaſon, I ſhall now explain that matter more fully. I have before obſerved, that in ſome animals not yet perforated, I found ſome other animals, from which the inſect before deſcribed hath been ſuffocated and killed. But in order to make this underſtood, we muſt obſerve, that the leaves of Willows are frequented by various ſpecies of inſects, which indeed lay their eggs either in or upon theſe leaves; and theſe eggs at length grow into vermicles, ſome with, others without feet. The unperforated tubercle, whereof I now treat, contained two kinds of animals; the Caterpillar, which I have deſcribed above, and a Worm without feet, both which lay together in the ſame cavity. But as both were nouriſhed with the ſubſtance of the tubercle, and both diſcharged their excrements into it; it happened, that the Caterpillar was ſuffocated, and ſo deſtroyed by its companion.

When I firſt ſaw ſome of theſe feetleſs Worms in the tubercle, I took them for the Caterpillars I deſcribed before, thinking, that thoſe ſprung from their eggs without feet; and afterwards, when they grew ſomewhat bigger, that their feet appeared. But at length I diſcovered, by repeated obſervations, that theſe feetleſs Worms are of a different ſpecies: though, notwithſtanding I am very certain, that their eggs are thruſt into the leaves of the Willow tree, in the ſame manner as the Caterpillar; and that the Vermicle that is to ſpring from thence, is there nouriſhed, and undergoes a change. The feetleſs Worm here mentioned, had already grown a little more than the Caterpillar. It has a paler head, and diſcharges a great deal of excrements: But becauſe, I never obſerved a conſiderable number of theſe Worms, in the warts or tubercles of Willow-leaves, which they only occaſionally inhabit; therefore the opportunity of inveſtigating their change to the Fly-ſtate failed me. Perhaps I ſhall hereafter take farther pains in this inquiry.

In another excreſcence, I found a third ſpecies of Worms, which were likewiſe without feet, and were twice as little as the former. Their head was formed almoſt in the ſame manner: but it was thicker, where it is joined to the thorax. I obſerved alſo, two black ſpots in the head, which probably were the eyes: theſe Vermicles changed their ſkin alſo, and crept pretty quick. Sometimes two of theſe are found in one tubercle; and they then live ſeparated by their excrements, as by a wall between them: this very thing I have likewiſe ſometimes obſerved, when their tubercles touched each other. Theſe Vermicles or Worms, likewiſe ſeem to undergo their changes within the excreſcences; but at this time, the excreſcence aſſumes a ruſty colour all over it. I have not yet diſtinctly ſeen their change; becauſe they are not found to be very common. It muſt be good fortune, if any one ſhould happen to diſcover the order, in which the limbs and parts of thoſe animals increaſe. I made theſe obſervations on the 28th of June.

When theſe feetleſs Worms have undergone their tranſmutation, or the Caterpillars, which I have deſcribed, have left their tubercles; ſo that theſe are open and empty, then various other little Worms with feet, viſit and hide themſelves in them, or caſt their eggs there, in order afterwards to nouriſh their young in thoſe cells. The ſmaller Spiders alſo frequently betake themſelves to theſe warts on leaves, that they may lie in wait, and catch the leſſer inſects that paſs by, and when caught, feed on them. For the Willow-leaves feed an infinite number of very ſmall inſects; ſo that a whole treatiſe might be wrote on the different ſpecies of minute inſects that are found about theſe trees.

Among other inſects, I found on theſe leaves a very ſmall Cicada; which, as to its changes, and its manner of living, is altogether like the larger Cicadæ of France and Italy. Very ſmall Caterpillars are likewiſe found there, affixing an oblong and gold-coloured web to the leaves; out of which ſome remarkable ſpecies of ſmall Flies are uſually afterwards produced. When thoſe Flies iſſue out of their little caſes, they likewiſe throw out of them an operculum or cover, which is exactly round, as I have related of the web of the Caterpillar, which I have deſcribed before and delineated.

Among the little inſects which come from without, into the tubercles, I have obſerved a very ſmall one, that was white, oblong, Tab. XLIV. VII. and has very great vital ſtrength. It had two black eyes, ſituated in the loweſt region of its head towards the thorax. Out of the forepart of its head projected two antennæ. It had ſix legs, over which were ſeen four wings, encloſed in little knots. The body appeared to be divided into rings. This little animal was changed afterwards in to a black oblong Fly, with wings as long as the body. But when this change happened, the inſect was not at all deprived of its motion; therefore it belongs to the ſecond order of changes. The reaſon why I deſcribe it under the fourth order, conſiſts in this, that its change is inwardly perfected in a concealed manner in the hollow tubercles of the Willows. It is ſo ſmall, that it can hardly be delineated in its natural ſize. One muſt therefore firſt know thoſe different modes of changes, and what inſects viſit the excreſcences of the Willows, before one can, without error, make experiments on this matter.

A particular deſcription of certain inſects, which live between the firſt and ſecond coat of the Willow leaves, and are changed into Beetles.

BESIDES the tubercles hitherto delineated, which contain the Caterpillar before deſcribed, there is likewiſe another ſpecies, Tab. XLIV. Fig. VIII. of Worms without feet, obſerved to lie between the outmoſt and inmoſt coat of the Willow leaves: theſe I ſhall now deſcribe, and delineate them magnified, but I ſhall firſt treat of the leaf itſelf. The Willow leaf, as I have obſerved before, conſiſts of three coats; whereof the inmoſt is the moſt ſucculent; and may therefore ſerve many inſects which eat the entire leaf for their proper food: but the Vermicles whereof I now treat, eat only the inmoſt part of the leaf, leaving the inward and outward coat entirely untouched: they do not indeed devour the little nerves of the inward fleſhy ſubſtance, but only the matter in their inteſtines. Since theſe Worms therefore conſumed only the middle of the Willow leaf, hence it is, that they are always found lying immediately under the inmoſt coat of that leaf; for this they eat and conſume by degrees on the inſide, until they come to the external coat, which very ſtrongly ſupports the nervous filaments of the leaf. Thus at length it happens, that the inſide of the Willow leaf is hollow underneath, and becomes ſeparated from the external: this is the reaſon alſo, why the two coats of this leaf grow dry in that part, and aſſume a ruſty colour: and this ſhews plainly, that the little animal lies between theſe two coats.

I ſometimes have found ſeventeen ſuch Worms in one Willow leaf, which then indeed appeared to be divided into ſo many ruſty coloured ſpots. In order to underſtand theſe matters more clearly, I have judged it proper to repreſent two of theſe ſpots in the natural ſize; whereof the one is cloſed, and the other open, Tab. XLIV. Fig. I. *zz*. In the open ſpot, it may be obſerved, that the inmoſt coat of the leaf is entirely removed from the middle larger nerve. It likewiſe appears there, that the ſmaller nerves of the one ſide, are entirely naked, and the matter that had filled their interſtices is conſumed. In the oppoſite ſide, beſides ſome excrements, there is ſeen the naked head of the Worm, together with the body, tranſparent through the elevated coat.

That what has been hitherto ſaid, as well as the method whereby the Worms performs all theſe matters, may be more clearly comprehended; I ſhall now delineate the inſect itſelf magnified, and ſhall deſcribe its external parts. This Worm, or Vermicle, has no feet; but it conſiſts of fourteen annular inciſions, which conſtitute its head, breaſt, belly, and tail. In the forepart of the head are ſeen two teeth *a*. The thorax, in that here repreſented, was very much expanded in breadth *bb*, and ſhewed in its firſt ring two ſpots of a ruſty colour, approaching to brown. The head alſo appeared to be of the like colour, but ſomewhat paler: there were alſo, very many tranſparent pulmonary tubes ſeen in the breaſt. The reſt of the body was formed *cc* nearly like the thorax. Out of the ſides of each ring of the thorax and belly there ſprung hairs like flaxen threads. The laſt rings of the body alſo, were variegated with ſome black ſpots. This whole Worm was of a beautiful white colour, ſomewhat approaching to green. It moved a ſlow pace, going forward by the aſſiſtance of the rings of its body; which it ſometimes contracted, and again expanded: and this it did more readily, whilſt it lay between the coats of the leaf, than when drawn out of it. The exuviæ, or skin which it caſts, was left between the coats of the leaf; where likewiſe lay the excrements, which the Worm had even thruſt into the hollow interſtices of the little nerves.

I have not yet ſeen the egg of this Vermicle, though I have very diligently ſearched for it; but I had begun that obſervation on the 20th of Auguſt, when the Summer draws to an end. I afterwards obſerved, that the Vermicles were too far advanced for me to be able to find out their proper conſtruction and hiſtory. The inveſtigation of that matter muſt therefore be deferred to another opportunity. However, even at that late ſeaſon of the year, I found, in a Willow-leaf, a very ſmall kind of orbicular ſpot, which I have figured therein, near the former ſpots, Tab. XLIV. Fig. I. *zz*. I expected to have found an egg in this; but when I opened it, I found a very ſmall oblong, black Nymph; which, I found on examining it with a microſcope, would at length change into a ſmall Beetle. But I could not then diſcover either the worm or the egg of this Nymph. When I attempted, and was deſirous to keep the Nymph, it was loſt from my ſight, on account of its extreme ſmallneſs. Conſider, reader, therefore, how minute that egg muſt be; the Nymph of which was almoſt inviſible. I began this obſervation on the 30th of Auguſt.

It is evident from what I have ſaid of the teeth of theſe Worms, with what inſtruments they gnaw and break open the inmoſt coat of the leaf. For the Worm, in a very irregular manner, hollows the leaf, forming a ſinus which runs into various angulated and ſerrated borders; by which means it widens its habitation by degrees, eating the ſubſtance of the leaf ſometimes round it, ſometimes lengthways, and at other times through the angulated curvatures. It is very admirable, that the Worm never eats even the ſmalleſt hole in the coats of the leaf. It ſeparates the internal from the external coat ſo carefully, and without injury, that the method whereby it is done would indeed be incomprehenſible; unleſs we conſider its fine teeth, by the help of which it conſumes the middle ſubſtance of the leaf. Hence it is likewiſe evident, that the orifice muſt be very ſmall, by which the egg of this Worm is firſt conveyed through the inward coat into the ſubſtance of the leaf, that it may live, be nouriſhed, and perform its metamorphoſis there.

On the 24th of Auguſt, I ſaw *a* Fig. x. one of theſe Vermicles put on the form of a Nymph in my chamber. This may be ſeen very exactly, by holding the leaf to the light of the ſun or candle. I obſerve, that this Nymph properly belongs to the firſt mode of the third order; ſince it very clearly, and without impediment, exhibit its limbs to view. In the beginning of this change, the Nymph is white; but it afterwards becomes gray, and by degrees black. It very ſtrongly moves its tail; by the help of which it can go between the coats of the leaf. On Auguſt the 26th, it became as black as pitch.

The head, thorax, abdomen, and all the other limbs of the future Beetle were now ſeen in it. In the forepart of the head were ſituated two crooked, Tab. XLIV. *a* briſtly hairs. In the lower part of the head, its mouth or trunk lay hidden in an oblong caſe. On each ſide, near the head, appeared the horns *bb*, elegantly compoſed, as it were, of little joints or knots. Near theſe was ſeen the firſt pair of legs; and under the latter another pair, out of which projected *cc* two briſtly hairs like two crooked prickles. Below theſe legs appeared the ſheaths or caſes of the wings; which proceeding from the back and bending, lay along upon the belly, and were beautifully divided with ribs *dd*. Underneath them lay the membranous wings themſelves, encloſed in a membrane; immediately under the caſes, the bending of the third pair of legs ſhewed itſelf: and this pair alſo was armed *ee* with rigid briſtly hairs. Next followed the rings of the body, and ſome prickles *f* projecting out of the tail; by the help of theſe the Beetle probably pierces the leaves. But this is merely conjectural; nor have I obſerved it, being then engaged in other buſineſs.

On the 30th of Auguſt, one of theſe Nymphs was changed into a Beetle, Fig. XII. after it had ſome days worn the appearance of a beautiful Nymph. When at the ſame time, I opened ſome other ſpots of the Willow-leaves; a great number of Nymphs preſented themſelves on the inſide; which when, after caſting their skin, they were changed into Beetles, I obſerved, eat thro' the leaves, and made very conſpicuous holes.

I have been informed by many travellers, that in hot climates, Worms are found in leaves an inch long: on theſe many fine experiments might have been made, if the inhabitants of thoſe places had not laboured under the curſed thirſt of gold, and prematurely broken the thread of life with intemperance. This Beetle is divided into a very beautiful head, thorax and tail. The eyes are very black, of a reticulated conſtruction, Tab. XLIV. Fig. XIII. *a*, and ſituated in the head at a very little diſtance from one another: under the eyes is ſeen a black, crooked ſnout, full of little cavities, and of a ſubſtance between bone and horn *b*, and on the forepart of the ſnout are placed the teeth of this Beetle. The little horns are very diſcernible, and are of the ſame colour with the ſkin of people who have been much expoſed to the ſun: they ariſe very gracefully from about the middle of the ſnout *cc*. They are each compoſed of eight joints, and are ſo thick at their ends, that they may very properly be called præpilata, or knobbed horns. The thorax conſiſts of a very black horny bone, and is full of white hairs, and little cavities; from the lower part of it ariſe ſix legs *ddd*; they are of a moderate thickneſs, but ſlenderer at their extremities. Theſe legs are covered with hairs, and with little irregular eminencies; in colour they reſemble the horns. Each leg conſiſts of ſix joints, and each foot of four, of which the laſt are armed with two nails. The ſecond joints of the two hinder feet are ſomewhat blackiſh, and much thicker in proportion, than the ſame joints in the fore legs.

The reaſon of this difference ſeems to be, that the former contain ſome very ſtrong muſcles, by means of which this inſect can ſpring on its hinder feet in the ſame manner as Flies, but ſomewhat ſlower. I ſaw one of them make a leap of three inches and a half, which is about twenty-eight times the length of the creature's body. The caſes of the wings are likewiſe black *ee*, but covered with a fine white down, and are ſurrounded with a ſmall border; they are alſo ribbed, and full of cavities; notwithſtanding which, they ſhine like the beſt poliſhed looking-glaſs. The wings are membranaceous, and twice as long as the caſes, ſo that to defend them, they muſt be folded up, which they accordingly do in a moſt exquiſite contrivance. Tho' I could eaſily procure inſects enough of this kind, I could not find time to diſſect them; for which reaſon I have nothing to ſay of their eggs, or of their genital, and other internal parts.

An account of ſome ſmall Worms that are bred within the new and tender leaves of Willows, and afterwards change to Flies.

ON the twenty-eighth of June I obſerved, in looking over ſome Willows, that ſome of their young leaves, which had but juſt made their appearance about the tops of the branches, began already to dry up and wither, Tab. XLIV. Fig. XIV. *a*. This was enough to engage my curioſity; and accordingly, I immediately ſet myſelf to diſcover the reaſon of ſo ſudden a decay. On ſeparating theſe withered leaves from one another, I found between them many collections of living Worms, to the number of eighteen or twenty together *b*, and as it were, in the moſt friendly and ſociable manner. Theſe inſects were of an oblong figure, but ſomewhat broader in the middle than at the extremities, and of a moſt delightful bright orange or ſaffron colour. Some of them had already begun to make their webs, and others were employed in preparing themſelves for it.

On this diſcovery I ſearched ſome other new leaves, and found in them a great variety of Worms of the ſame ſpecies, ſome more grown than others. I found alſo in ſome of the leaves the eggs from which theſe Worms had been hatched; but they were lodged only between the folds of the leaves, and not within their ſubſtance, as was the caſe in the laſt obſervation.

Theſe Worms lived merely upon the juices flowing from the leaves where I found them; but as this juice is very tough or viſcous, it may naturally contain ſufficient nouriſhment for them, and ſo render unneceſſary their preying on the ſubſtance of the leaf itſelf. Whether this juice flowed ſpontaneouſly from the leaves, or whether they made inciſions in them to extract it, is a thing which I cannot take upon me to determine. I never ſaw any of theſe Worms ſtir from under the folds, and wrinkles of the leaves, but obſerved, that they conſtantly crawled under cover, from one cavity to another, till they had attained their full growth, and the embryo limbs contained under their ſkins, were arrived, by the due degrees, at a proper ſize, to prepare for their ſucceeding appearance.

When the leaves, whoſe greenneſs and growth is deſtroyed by theſe Worms, begin to harden and dry up, the Worms, without ſtirring from under cover, form themſelves webs, in which they at length become Nymphs. They make their webs ſtronger and thicker about the head and thorax, than elſewhere, as theſe parts are to be the chief ſcene of the enſuing changes, and of the growth of new limbs; and therefore require an extraordinary bulwark to defend them, eſpecially as the leaves about this time grow very hard and rugged, and therefore more apt to cruſh, and otherwiſe hurt the encloſed inſects. As theſe communities of Worms live under one cover, and in a kind of brotherly ſtate, on the ſame ſpot, they form their webs one cloſe to another, without any diſturbance and encroachment one on another.

The Nymph of this Worm is very ſmall, but it exhibits, notwithſtanding in its parts, the figure of the future Fly. It loſes all manner of ſenſible motion, except in the tail, which it is ſtill able to ſtir with great violence. On the fourth of July, I obſerved that theſe inſects were turned to Flies, which appeared through the microſcope, of a moſt delicate conſtruction, Tab. XLIV. Fig. XV. The head reſembling that of a pin, was joined to the thorax by a very fine and ſlender neck. On the forepart of the head, were placed two oblong horns. It had ſix long black legs, and wings longer than the body, which glittered like mother of pearl. The body ſcarce differed in colour from that of the Worm. This Fly, when moving through the air, appears no bigger than an atom of duſt. It is very ſurpriſing how ingenuous theſe little animals are in depoſiting their eggs within the tender buds of ſuch leaves as are fit to afford ſhelter and nouriſhment to the Worms that are to riſe from them, that, by this means, they may be able, in obedience to the immutable laws of nature, to renew their ſpecies from year to year, and continue it even to the end of the world.

Of Worms which are found encloſed in tubercles like Roſes, that appear on the tops of Willow branches; and likewiſe in many of the dwarf Willows that grow upon heaths and commons.

WE not unfrequently ſee a tubercle formed at the ends of Willow branches, in the ſhape of a Roſe *, and which the learned Mouffet accordingly calls by that name, Fig. XVI. *a.* In ſome ſeaſons, theſe tubercles appear in great numbers, and in others, they are ſcarce. I once obſerved, in company with Meſſieurs Thevenot and Henon, that there was hardly a ſingle Willow branch in all the open country, that lies near a little ſea-town called Egmont, which had not one of theſe tubercles at its extremity.

After breaking off the external leaves of this tubercle, there appears in the middle an aſſemblage of other tender leaves, in form of a pear, Fig. XVI. *b*; which lie one over another, in the ſame manner with the innermoſt leaves of the Cinara or Artichoke, ſo as to make it neceſſary to pull them off one by one, Fig. XVII. *c.* in order to obtain a ſight of the Worm, *d*, which lies hid within them, wrapped up in a tender and delicate membrane, or kind of web, *e.* This Worm lies there in an inverted poſture, with its head the loweſt, and its tail the higheſt part of its body; and it is ſo narrowly confined within its web, and in the ſurrounding leaves, that it ſeems very probable, it cannot either move at all, or, at moſt, not without great difficulty: in this reſpect, it differs extremely from all the other Worms that have been before deſcribed. On extracting it from the place of its birth, *f*, its body appears compoſed of various rings, and is ſomewhat ſlenderer towards the tail, than the head. Its colour is of a florid red, and by no means unhandſome.

The food of this Worm is no other than the juices of the Willow, flowing to the extremities of the branches, where the inſect is moſt conveniently placed to receive them. There is not the leaſt excrement to be found with this Worm, nor indeed with thoſe laſt deſcribed, which makes it probable, that, like the fœtus, while it lives in the mother's womb, and is there ſubſiſted by nouriſhment, taken in after a peculiar manner, theſe inſects retain their excrements till they appear in the Fly-ſtate. I omitted unfortunately diſſecting this inſect, though, by doing ſo, I might have attained perhaps a ſatisfactory ſolution of this uncommon circumſtance. I could not have found any difficulty in inveſtigating the matter that way, as I could eaſily have procured what number of theſe inſects I pleaſed: but our negligence and inattention are ſo great, that we generally deſpiſe thoſe things that are under our hands, to ſatisfy an inordinate curioſity of knowing and poſſeſſing thoſe which lie at a greater diſtance, and are hard to be obtained. The beſt of us muſt own himſelf ſo far the ſlave of vanity, as to be more deſirous of producing any thing foreign and unheard of, than that which is ſpontaneous in our own country. Though the Majeſty and Wiſdom of God, the fountain of all revealed wonders, moſt evidently ſhew themſelves the objects of our love, praiſe, and adoration, equally in every creature.

A fault of the ſame inexcuſable kind, made me forget myſelf ſo far, as to neglect examining the egg of this inſect, though the little roſe, which had firſt engaged my attention, is produced merely to cheriſh it. This is plain from the Willow branches never bearing any ſuch excreſcences, unleſs theſe Worms are in them; for, when the parent inſects happen not to depoſit their eggs at the extremities of the branches, they ſhoot into ſeparate leaves of the common form. Theſe Worms perform their changes for the Fly-ſtate at two different periods, namely about mid-ſummer, and in ſpring, when the Willows begin to bud. Thoſe which aſſume the Nymph-ſtate, Tab. XLIV. Fig. XVII. *g*, in ſummer, without ſtirring from the place of their birth, in a few days after become Flies, *h.* But ſuch as happen not to be changed to Nymphs till autumn, continue encloſed in their covertures till the enſuing ſpring; when, on the ſun's nearer approach, they likewiſe become Flies: all theſe Flies immediately betake themſelves to the Willows, where they may be ſure their offspring will find convenient food and lodging.

The Fly is of a middle ſize, but of a very delicate conſtruction. The extremity of its body is armed with an aculeus or ſharp weapon, by means of which, it may open a paſſage for its eggs into the tender tops of the Willow branches. It has two horns on the forepart of its head, two membranaceous and conſiderably long wings, and ſix long ſlender legs, formed very like thoſe of the common Gnat. As to its colour, I forgot to obſerve it particularly. Thoſe Flies which I dried, in order to keep by me, are of a dark gray. I have ſometimes obſerved four Flies to proceed from one of thoſe Willow roſes, but they were four times leſs than thoſe kinds, which require each a whole roſe to itſelf. Theſe ſmaller Flies were of a reſplendent jetty black colour, had ſix legs, and ſhorter horns than the other kind. Their two wings were adorned with a black ſpot, each in the middle of its extremity: ſome of them alſo were provided with a ſharp aculeus or weapon at the tail *.

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* This peculiar excreſcence of the Willow, we have very common in the fenny counties in England. I have ſeen them on the edge of Lincolnſhire, as large as a common red roſe, and very double. In this ſtate they make a very beautiful, as well as peculiar, appearance: and our old Engliſh botaniſts, who were not acquainted with this part of natural hiſtory, ſuppoſed the tree a diſtinct ſpecies, and called it Salix Roſea, the Roſe-Willow.

At preſent I can ſay no more of theſe Flies, being ſo much taken up with other buſineſs at the time of my writing theſe obſervations, that I have not leiſure duly to reviſe them. I muſt therefore refer this taſk to another opportunity, if it ſhould pleaſe God, the diſpoſer of all things, to offer me the means of performing it.

Of certain Worms without feet, found in the Hazel-nut.

THESE Worms are ſo common, and ſo eaſily to be had, that a deſcription of them may ſeem in ſome degrees ſuperfluous. Their bodies are white, ſoft and hairy, their heads are red, and armed with two ſharp teeth, with which, in autumn, they bore themſelves a paſſage through thoſe nuts in which they had hitherto reſided; but which they then forſake. Theſe Worms may be found ſometimes lying in hundreds together, at the bottom of drawers and baſkets, in which hazel nuts have been kept. I have often formed a reſolution of examining accurately the nature and diſpoſitions of theſe Worms, but have not as yet an opportunity of doing ſo. Nevertheleſs, I ſee no reaſon to doubt, but that they, as well as all other animals, derive their origin from an egg, thruſt from abroad into the ſubſtance of the young nut, or perhaps into the bud or flower, out of which it is to be formed, as has been already obſerved, of many other little animals of this kind.

There is no keeping theſe Worms in dry boxes; for they will live in this confinement but a few weeks. But in pretty moiſt ſand, ſome of them have ſurvived with me the rigour of a whole winter, and lived to the 24th of March; and all that time without any food. Some of them, after undergoing this ſevere treatment, were yet vigorous enough to ſet about their mutations: but, by digging continually into the ſand, in order to ſatisfy my curioſity, in ſeeing what they were doing, I wounded ſo many of them, that as yet I have not been able to diſcover what kind of creature they finally become.

I obſerved beſides, that ſome of them burrowed much deeper into the ſand than others; and I even found ſome at three inches under the ſurface. I never could perceive any web about them, nor do I believe that they form any, as they always appeared lying in the ſand entirely naked. Nevertheleſs, I do not think there is any reaſon to doubt, but when theſe Worms eſcape from the nuts, and leave the hazel ſhrub to live in or under the ground; they, in this laſt ſituation, change to Nymphs, and afterwards, in the enſuing ſpring, to a kind of Flies, which again depoſit in the tender rudiments of young nuts, eggs, like thoſe from which themſelves originally were produced. It would be no difficult matter to aſcertain, by experiment, the truth of this conjecture.

Of Worms found between the two coats of the Alder-leaf.

FIRST OBSERVATION.

ON examining ſome Alder-leaves on the 20th of Auguſt, I obſerved the ſubſtance lying under the ſurface, formed by the internal coat of the leaf, was in many of them irregularly gnawed away in little angular cavities, without any paſſage to the outſide of the leaf, that I could diſcover; nor had the leaves, in which theſe cavities appeared, loſt any thing of their greenneſs or freſh hue, as the Willow-leaf juſt ſpoke of had done. The internal coat, hollowed in this manner, roſe conſiderably above each hollow, into a kind of little canopy, Tab. XLIV. Fig. XVIII. *a*, whereas, on the oppoſite parts, the other ſide of the leaf, which is covered by the external coat, was only a little altered by a few ſmall wrinkles, *b b*; this no doubt was the true cauſe of the extraordinary roundneſs and convexity of the oppoſite tumor.

On opening one of theſe ſwellings, I diſcovered between the two coats of the leaf now ſpoken of, a perfect web, formed exactly like that of the Moth in its Worm-ſtate; and, on opening this web, I diſcovered a Chryſalis, *c*, in point of ſhape and conſtruction, plainly belonging to the ſecond mode of the third order of changes. The ſkins under which this inſect had lived in the Worm-ſtate, lay near it under the ſame web. I could alſo diſcern that it was, by means of this web, the Worm had reduced the ſurface of its cavity, formed by the external leaf, to the appearance already deſcribed. On each ſide of the web lay the Worm's excrements. The method uſed by this Worm, to form itſelf, between the two coats of a leaf, a cavern or neſt in which it may conveniently perform its mutations, is certainly one of the moſt ſurpriſing objects that natural hiſtory offers to our conſideration.

As to the Worms themſelves, I could not diſcover any of them, or any of the eggs, out of which they muſt have been hatched. In all the leaves I examined for this purpoſe, there appeared nothing, only webs; ſo that the ſeaſon, for finding eggs or Worms was certainly elapſed, at the time when I looked for them. The Chryſalis,

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* The females have all of them this weapon at their tail; the males never. The reaſon is very plain, for its uſe is to bore a hole in which to lodge the eggs; therefore only the female has occaſion for it. This author has obſerved the ſame on other occaſions, in various ſpecies of Flies.

ſalis, viewed through a microſcope, plainly exhibited the form of the Butterfly, to which it was thereafter to be changed. It was oblong, ſomewhat flatted and broad on the fore part, where it terminated in a point, Tab. XLIV. Fig. XIX. *a*, whilſt its hinder part grew gradually narrower, ſo as to reſemble a pyramid or cone, *b*. Each ſide of the body was covered with a few, very delicate hairs, *c c*. Its ſurface was of a pale brown colour. The eyes appeared on the head, *d d*, and under them a double trunk *e*. A little lower down, and juſt by this, the firſt and ſecond pairs of legs were ſeen, *f f*. The antennæ or horns, which were of an extraordinary length, extended from the eyes to the very extremities of the two firſt pairs of legs, *g g g g*. Near theſe lay the wings, *h h*. The hinder pair of legs was placed between the antennæ, and ſtretched beyond the extremities of theſe parts, *i*. The body conſiſted of ſeveral rings, *k k*. This Chryſalis looked as if it had caſt its ſkin but a few days, and it moved its tail very vigorouſly, making uſe of it to turn itſelf, and indeed to move from one place to another.

On the 26th of Auguſt, two of theſe Aureliæ yielded two very elegant Butterflies, leſs than Moths of cloaths; but like them in colouring and ornaments, as may be ſeen by the drawing I have given of them, where they are repreſented of their natural ſize, Fig. XX. It is hardly poſſible to conceive a more beautiful little animal, than what this Butterfly appeared to be, when viewed with a microſcope, Fig. XXI. It conſiſted of a head, thorax, and abdomen. The head was furniſhed with two antennæ or horns, *a a*, and a ſhort and crooked double proboſcis or trunk, *b*. From the ſhoulder blades of the thorax ſpring four wings, and from the under part ſix legs. The wings were partly of a mere membranaceous ſubſtance, and partly compoſed of delicate feathers, or ſcaly hairs. The upper pair ſhone and glittered moſt gloriouſly with creſcents of gold, ſilver, and brown, *c c*, ſurrounded by borders of a delicate black: beſides this, they had a black ſpot at the extremity of each. Moreover, theſe extremities were edged with little feathers, which made them look like a creſt, when they lay cloſe upon the body, one folded over the other. The lower wings are likewiſe in a great meaſure covered with feathers, *d d*, and are of a pale colour, and ſilvery brightneſs. Along the middle of the wings there runs a membranaceous little ſtem, from which iſſue the feathers that, in a manner, compoſe them; and even this ſtem has, as it were, its own ſcaly feathers to defend and adorn it.

All the ornaments beſtowed with ſuch profuſion on the wings of this little inſect, conſiſt in reality of feathered ſcales of different lengths, and various diverſified colours; and they are divided, more or leſs, into lateral branches, like the feathers of the larger winged animals. The colours are more lively or faint, according as the ſcales forming them lie together in greater or ſmaller quantities; and from the ſame conſtruction, and contrivance alone, reſults all that ſtriking variety in the wings of Butterflies: for, on rubbing of their feathers, they appear entirely even and plain, like the ſurfaces of all other membranes.

The legs of this Butterfly are entirely covered with the ſame kind of plumage, and they are divided into joints: every extreme or loweſt joint is armed with two little claws. The hinder legs have, beſides theſe, three little white prickles, or ſpurs, Tab. XLIV. Fig. XXI. *e e*. The body is divided into rings, and covered likewiſe with feathered ſcales of a bright ſilver whiteneſs. This little animal, being put in a box that had ſerved to keep Brazil-ſnuff, began immediately to tremble, and in leſs than two minutes expired in a convulſion that ſeized every limb. As yet I have made no more obſervations of this inſect. The ſurpriſing manner wherein the Worm, from which it is produced, neſtles and feeds between the coats of the Alder-leaf, will, I hope, alone be judged ſufficient to recommend to the curious what I have ſaid upon this occaſion.

SECOND OBSERVATION.

THE 30th day of Auguſt I found, between the ſame coats of Alder-leaves, a flattiſh Worm, of the ſize and form repreſented at the letter *d*, Fig. XVIII. as it appeared on removing from it a part of the coat belonging to the leaf on which it had fed. The body was oblong, and ſomewhat broader about the thorax than at the belly or tail. The head was large, of a pale brown colour, ſomewhat flattiſh or depreſſed; and on its fore part furniſhed with two eyes, and a pair of ſharp teeth. From each ſide of the lower part of the thorax there aroſe three legs. In the tranſparent body there appeared a little green ſtreak, produced by the Worm's food. Counting the head and tail, this Worm conſiſted of twelve rings.

I diſcovered alſo, that this inſect had caſt a ſkin, in the ſame place where I found it. The internal ſubſtance of the leaves, where it reſides, ſerves it for food; and it had accordingly gnawed this ſubſtance away, without offering to touch the adjacent coats, into a great many windings and turnings. As this parenchyma, or pulpy matter, had been but lately devoured, the leaf, even in the ſpot where the devaſtation had been made, ſtill retained its verdure; but ſoon after it withered, and changed to the colour of the leaves of the Alder that fall in Autumn. The external coat of the leaf, in which the ribs appeared, was very ſtrong and thick; but the other ſide, or internal coat, was very thin and delicate. The excrements, which were at firſt green, and then grew black, rolled freely backwards and forwards within theſe two coats. I could not diſcover in theſe leaves the ſmalleſt opening, by which the encloſed

Worm might be ſuppoſed to have inſinuated itſelf into their ſubſtance. Some of the Worms within theſe coats were dead, which I attributed to the ſtriking of the leaves againſt one another with the wind; or to their withering and wrinkling up, for want of nouriſhment; or, finally, on account of other external injuries. As yet I have had no opportunity of tracing this inſect through its changes, ſo that I have nothing more to ſay here concerning it; but that it was very delicate, and moved itſelf but weakly. On taking it from within the leaves, it died in a day or two. The Alder is not the only tree inhabited by theſe Worms: they are to be found alſo on the Pear and Apple, and many other kinds.

THIRD OBSERVATION.

ON the 31ſt of Auguſt I found, within the ſame coats of certain Alder-leaves, a third ſpecies of Worms which had no feet, and were divided into twelve rings. This ſpecies had a much rounder body, Tab. XLIV. Fig. xviii. *e*, than the firſt, with a very ſmall head and teeth. The back and belly were diverſified with various white ſpots, which appeared through a yellowiſh green tranſparent ſubſtance, and ſeemed to me to be ſo many particles of fat. The neſt which this Worm had gnawed itſelf within the coats of the leaf, was not ſo ſpacious as thoſe of the two Worms laſt treated of; and ſometimes one neſt contained two Worms, which lived and fed together in common; but in this caſe, the neſt was ſomewhat larger. In another leaf I found two of theſe Worms, that had each formed itſelf an oblong web, *f*. In the ſame place I alſo found their excrements, and the ſkins they had caſt off.

Theſe webs were red, as were alſo the ſhrivelled coats of the leaf that contained them. On opening one of theſe webs, in hopes of finding a Nymph, I met with a Worm, which as yet had ſuffered no change, except that of being grown a great deal ſmaller than before; and it was impoſſible it ſhould not have loſt ſomewhat of its bulk, conſidering the great quantity of ſilk it had drawn from its body, to form itſelf a covering. Four weeks after this, I opened another web, little thinking that I ſhould meet with a ſecond diſappointment, yet ſo it happened; for there was no Nymph even yet, but only the Worm lay there quite unaltered. I have therefore laid by ſome of theſe webs, in order to diſcover next year, if poſſible, what kind of an inſect they produce, which is poſſeſſed of the ſurpriſing art or power, as a faculty of burying its eggs thus ſubtilely within the two coats of leaves. When theſe Worms are very ſmall, their neſts, which they gnaw themſelves, are very ſmall likewiſe, Tab. XLIV. Fig. xviii. *g*; but they widen proportionably by degrees, *h i*, as their inhabitants grow bigger and bigger. From whence I conclude, that the holes in which they have been originally depoſited, in form of eggs, muſt have been of a minuteneſs almoſt beyond conception. But, as yet, I have no experiments or obſervations to enable me to ſay any thing certain on this head.

The ſame ſubject continued. Hiſtories of inſects that are found in fruits, tubercles or warts, and leaves of plants. An obſervation on the common Thiſtle growing in the fields of Holland.

WAlking about the middle of ſummer into the country, in order to find leaves for Caterpillars I was at that time feeding, I happened to obſerve on a common Thiſtle, not as yet arrived at its full growth, a yellowiſh ſlender Fly, Tab. XLV. Fig. I. *a*, with a large head, red eyes, two ſhort antennæ, and wings very elegantly coloured. This inſect had thruſt out, to a very great length, the extremity of its uterus or womb; and was employed in endeavouring to bore, by means of this part, a hole into the ſubſtance of the leaves, wherein it might depoſit its eggs. This curious ſight could not fail of engaging my attention, and accordingly I ſpent a long time in viewing it, equally aſtoniſhed at its novelty, and overjoyed at having an opportunity of ſeeing, with my own eyes, the manner in which this kind of inſects attack the plants, which are proper to afford their Worm-offſpring a never-failing food and ſhelter: as likewiſe to obſerve their method of conveying into theſe plants the eggs from which their Worms are to proceed. In that part of the plant where theſe eggs have been depoſited, there afterwards grows a large globus, or round tumour, in ſubſtance not unlike the calix or cup of the Hazel-nut, which by degrees becomes ligneous, and hardens to a more compact ſubſtance, reſembling wood. Within theſe ſwellings there appear, here and there, certain white Worms, which change firſt to Nymphs, and then to Flies. Some pretend this Worm, carried in a purſe, along with its tubercle or ſwelling, is good againſt the piles.

Of Worms found within the tubercles or ſwellings of the ſtinging Nettle.

IT is very remarkable, that even in ſome ſtinging Nettles we meet with Worms, which are deſtitute of feet, and derive their origin from a very ſmall but yet diſcernible egg. Theſe excreſcences are found on the Nettle, in a great variety of forms. Some are produced upon the ſtalk, Tab. XLV. Fig. II. *a*; others on the ribs of leaves, or the tender buds, *b*: ſome again lie confuſedly, here and there, all over the ſurface of the leaves, *c*. The ſubſtance, of which theſe ſwellings are formed, is very hard and compact, which makes it an eaſy matter to crack them. In colour they are ſomewhat of a yellowiſh green. On the 28th of June I found a great many, both eggs and worms, in theſe ſwellings. The ſmalleſt of them contained each one egg; thoſe ſomewhat larger, a worm; and the largeſt of all, which were compoſed of two or three of theſe ſwellings growing together, afforded ſhelter to two, three, or even four Worms of different ſizes, and all this at one time.

The largeſt of the Worms I diſcovered at this period, were exactly of the ſame ſize with that, whoſe form, taken from the life, I exhibit in this figure, Fig. III. *d*. This Worm, viewed with a microſcope, appeared ſomewhat broad, and depreſſed in the middle, *e*, and armed on its forepart with a delicate ſlender ſnout, *f*; its body was almoſt white, but a yellow ſtreak appeared within it, which the Worm's tranſparency rendered very diſcernible. I found afterwards that this was an inteſtine, and that the colour of it was entirely owing to its contents. The ſkin of theſe Worms had ſome delicate hairs ſcattered looſely here and there over its ſurface, *g*.

On opening ſome more of the ſwellings on this plant on the third of July, I found ſome of the encloſed inſects were changed into Nymphs. Such of them as had lately caſt their ſkins were white, but the older Nymphs exhibited a variety of colours. Theſe Nymphs belong to the firſt mode of the third order; for it was eaſy to diſcover in their limbs the form of the future Fly. They very plainly appeared to conſiſt of a head, thorax, and belly. In the head, I could diſcern two remarkable eyes, Fig. IV. *h*, of a reticular form, which were beginning to look red; and on the ſides of the head the horns, legs, and wings, were curiouſly folded up, and might be ſeen ſpringing from the thorax. The rings of the body were very conſpicuous, and it had a little tail bent back, ſo as to lie over them in a very elegant manner, *i*. All theſe parts, the legs and wings excepted, were changed by degrees from white to yellow, which they afterwards loſt, to aſſume a deep brown colour, and finally a perfect black.

On the ninth of July, many of theſe tubercles were burſt open; and they no longer contained any inſects, but only ſome of the caſt-off ſkins. This gave me room to judge, that the Nymphs I had obſerved on the third of this month, had paſſed in the interval from that time, into the Fly-ſtate, and my conjecture was confirmed by what happened in the tubercles I kept at home in boxes. To me it appears probable, that all theſe tubercles open of themſelves *, at the time when the encloſed inſect has its wings, and is in readineſs to launch out into the air; and this may ſerve to account for my finding Nymphs at this very time, in ſome other tubercles which remained unopened, which had not as yet acquired their proper colouring, nor ſtrength enough to caſt their ſkins.

The Fly thus produced *k*, is furniſhed on the forepart of its head, with two longiſh black horns. The head is of a duſky brown, with a fine tinge of blueiſh green: and the eyes are red: from the upper part of the thorax ariſe four membranaceous wings, and from the lower ſix legs of a colour between red and white. In the males the body ends in a little tail, divided into two ſtiff hairs, or in a forked manner; ſo that this Fly is to be referred to the order that takes its name from this circumſtance, Biſetæ; but in the females, this part terminates in a pointed weapon. The breaſt and body of theſe Flies is of a very delicate and reſplendent green, like that of Spaniſh Flies, or Cantharides, ſo as to afford, when viewed with the microſcope, a moſt entertaining and elegant ſpectacle. I unfortunately omitted diſſecting theſe inſects. To preſerve theſe Flies and their Nymphs, I extend their limbs on white paper, and there faſten them down with a little moiſt ſtarch, for they are too delicate to be fixed upon pins.

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* So far as I have obſerved in theſe caſes, the Fly, when perfect, gets out of the tubercle two ways, but both are by violence, not by the natural opening of the tubercle. Sometimes the ſubſtance is ſo hard, that the Fly is forced with great labour, to gnaw its way out: in other inſtances, the covering is by this time become nothing more than a thin, dry, and brittle membrane; and the ſucceſſive ſwellings of the Fly's head, which have been mentioned on a former occaſion, burſt the rind and let it out.

Of the Worms that are found in ſome downy excreſcencies of Oak-trees.

THE Oak-tree affords ſhelter and nouriſhment to as great a variety of inſects as the Willow; of this, at preſent, I ſhall produce only two inſtances. The firſt I take from the inſects which breed within a kind of downy or ſoft excreſcence at the extremities of the branches; the ſecond from certain other kinds which we find encloſed in a moſt remarkable and ſurpriſing manner, within the tubercles ariſing on the leaves. This woolly or downy excreſence, of which I now intend to ſpeak, is found in the form of a ball, Tab. XLV. Fig. VI. *aaa*, and is made up of a ſoft thready matter, like wool or cotton: it is compoſed of very delicate hairs, running in every direction ſo as to form a very firm and ſubſtantial web; but the hairs are not very ſtrong in themſelves, for they are hollow, and look as if they conſiſted of ſmall globules. They ariſe from the footſtalk, or from tops of the Oak branches *b*, and ſometimes from the leaf, which in many inſtances ſhoots, as it were, from the central part of the excreſcence *c*, ſo as to appear entirely ſurrounded with this down. But the principal foundation of theſe hairs is no other than ſome little oblong hollow bags or tubes, Fig. VII. *d*, if I may give them that name, which are at firſt ſoft and tender like purſes, but afterwards harden to the firmneſs, as it were, of wooden pipes.

Each of theſe cavities is conſtantly found to contain one Worm, which lies hid, and grows in them, till it changes in the Summer months to a Nymph, properly belonging to the firſt mode of our third order. Nevertheleſs, as I have already often hinted, I rank theſe inſects in the fourth order, becauſe they perform their changes in a dark and myſterious manner, which nothing but the indefatigable diligence and attention of the curious can bring to light. It is owing to this that theſe inſects have been hitherto treated, not according to the laws common to other animals, in which the great Creator has been pleaſed more openly to manifeſt his glory, but according to falſe notions, ſuggeſted by our human ignorance and prejudice. I muſt here, however, do juſtice to the illuſtrious Redi, who has treated the works of nature in a very different manner, and thereby reſcued the operations of that great but ſubordinate agent, from thoſe thick clouds of darkneſs which human error and ignorance had raiſed about them: by what other name can we call that abſurd opinion, which attributes every thing to chance and putrefaction. Certainly, whatever allowances we may make on this occaſion, to the generality of mankind, thoſe among them, who would be thought people of ſenſe and learning, are altogether inexcuſable in countenancing ſuch a thought. This groſs error is the natural conſequence of mens manner of proceeding, when contented with ſitting quietly in their ſtudies, and looking over books, they neglect to trace the ways of God, the great Author of all things, in his works, which ſurround us on every ſide, neglecting them, to follow the deluſions of their own feeble imaginations.

The cavities now mentioned, are ſometimes found to the number of ninety, or even a hundred, or more, growing through one another, and wrapped about in the woolly down, or cottony matter that is lodged in the ſame place. When the Worms, encloſed in them, have changed to Nymphs, and afterwards acquired their proper degree of ſtrength, they each throw off a delicate ſkin, and are thus turned to very ſmall Flies; then they bore with their teeth through both the little tubes in which they hitherto have lain concealed, and the down that ſurrounds them, and then iſſue forth at a great many openings, Tab. XLV. Fig. VI. *ee*, in a very entertaining manner. On this occaſion, ignorant ſpectators are loſt in wonder, and form to themſelves variety of ſyſtems to explain ſo unuſual an appearance; but when they come to relate their opinions, we generally find them void of reaſon, and altogether ridiculous.

The Fly produced from theſe Worms, is divided into a head, thorax, and body, Fig. VIII. *f*. The head is furniſhed with eyes, and it has two long antennæ. From the upper part of the thorax ſpring four membranaceous wings, that ſhine like mother of pearl, and the upper pair are adorned alſo with two black ſpots, and with ſeveral very pretty ramifications of the nerves. To the under part of the thorax are fixed ſix tranſparent legs of a delicate rediſh brown colour. The body conſiſts of ſeveral rings, and is armed, at its extremity, with a weapon of an oblong form that is plainly diſcernible: no doubt, this is the inſtrument with which the inſect pierces the Oak branches, in order to depoſit its eggs within their ſubſtance. This Fly is altogether black in the body. I have not yet had the good fortune of diſcovering its eggs, either in the excreſcencies wherein they are hatched, nor in the body of the female, as I never have diſſected any of them. I made the foregoing obſervations on the 26th of June, when a great many of theſe ſurpriſing Flies iſſued from their neſts, which they likewiſe continued to do, till the 8th of July. The males were ſmaller than the females.

Of ſome little inſects that are found concealed in the tubercules, or ſwellings of Oak-leaves, in ſo artful and wonderful a manner, that the foregoing relations muſt yield the preference to their hiſtory.

THE obſervation I am now about to exhibit, is ſo uncommon in its kind, that nature perhaps cannot furniſh any thing to excel it. On this occaſion the infinite power and wiſdom of the Great Sovereign of the univerſe ſtrikes our eyes with its full luſtre, and indeed ſo plainly ſhine forth in his creatures, that we muſt conſider the meaneſt of them as ſo many voices engaged in publiſhing his praiſe; and thereby putting us in mind to yield him that tribute of love and adoration, which we owe on ſo many accounts: us, I ſay, on whom he has beſtowed the ineſtimable faculties neceſſary to inveſtigate and conſider him in his works.

To proceed with due order in this relation, I ſhall firſt deſcribe the excreſcences of the Oak-leaves, in which theſe wonders are found *, and add a figure to render the deſcription more intelligible. I ſhall then, in the ſame manner, give a ſatisfactory account of the inſect bred in theſe excreſcences, as it appears in the Worm, Nymph, and Fly-ſtate. As to the excreſcences themſelves, the particulars in them moſt worthy of our attention, are their ſituation, conſtruction, figure, colour, and ſize. Their ſituation is irregular, and it is pretty like that of the excreſcences on nettle-leaves already deſcribed. Some lie on the fore part of the leaf, upon or cloſe along the ſides of its nerves or ribs, Tab. XLV. Fig. XII. *aa.* Others appear in the middle of a leaf, ſeated upon the main rib, *b.* And ſome, in fine, are ſcattered confuſedly about the edges, *c c.*

Theſe tubercles conſiſt of a hard, knotty, and compact, but brittle, ſubſtance, without the leaſt toughneſs; ſo that, in this reſpect, they very much reſemble a cartilage. But, upon the whole, I know nothing to which this ſubſtance may be more juſtly compared, than to the cup or covering of the hazel-nut or filbert, before it ripens, or has been pulled. Theſe tubercles, or ſwellings, are formed between the two coats of the oak-leaf, and acquire their hardneſs when the delicate parent Fly has buried its eggs there. Theſe tubercles are ſometimes round, ſometimes oval or oblong; and we often meet with two, three, or four of them growing into one, ſo as, in a manner, to compoſe but one continued body. Their colour is generally a deep green, ſometimes a watery ſky-blue, and in ſome inclining to white and yellow. In point of ſize they differ greatly, according to their age, or perfection of growth, and their joining two or more into one tubercle, *b.*

I have not as yet had the ſatisfaction of ſeeing the firſt rudiments of theſe tubercles, which firſt I took notice of by mere chance, in company with my much honoured friends, the principal magiſtrate of Niewenrode and his lady, in the Hague-wood, from whence I took many of them home to examine at my leiſure. I ſhall, therefore, now deſcribe thoſe wonders I obſerved in them, in the courſe of a moſt diligent inquiry. In one of the largeſt of theſe tubercles, which I opened by paring off its upper part, Fig. XIII. *d,* I found a pretty large cavity, in which there again appeared three other peculiar or ſeparate excreſcences, *e.* As to the manner of their coming there, it is more than I can conceive. Theſe ſmaller excreſcences lay ſingly each within a kind of hollow, but without any partition between them. On taking out theſe three ſeparate excreſcences, *f,* I found that in figure they greatly reſembled a kidney-bean, which has one ſide more convex than the other. On inſpecting them with a microſcope, they looked as if they had been connected by the middle to a kind of pod, by means of a petiolus, or little ſtalk.

Theſe ſingularities ſerved only to make my curioſity more eager, to examine attentively the other tubercles that I had taken home with me; and I found them all filled with the miracles of the Great Creator. On ſeparating in the middle a tubercle, that wanted a great deal of being arrived at the ſize and perfection of that already deſcribed, I found no hollow or void ſpace within it; but only two ſuch pea-ſhaped ſubſtances as I have before taken notice of, and two little Worms, which I had cut in two, along with thoſe ſubſtances. All this is plainly ſhewn in the figure I give of them, Tab. XLV. Fig. XIV. little larger than nature; in which may be ſeen the two diſſected or cut ſubſtances, ſituated in the middle, and about them the ſubſtance of the tubercle, by which they are cloſely ſurrounded, like the ſeeds of an orange by its pulp. I could likewiſe obſerve, that the external coat or ſhell of the tubercle was much more compact, and of a greener colour, than the inſide; which difference I have endeavoured to repreſent in the figure, as if there had been a ſeparation between the differing ſubſtances, though, in reality, there is no ſeparation in this ſtate of the production.

On opening a third tubercle, that was ſomewhat more grown, I could diſcern that its internal ſubſtance was drying up by degrees, and ſeparating from the encloſed kidney-bean-like ſubſtance; by which means this came at laſt to lie in the tubercle as within a hollow, and to reſt againſt one ſide or another of this hollow. In this manner I plainly diſcovered, that the three detached ſubſtances, in the tubercle I firſt opened, had obtained, by evaporation, that wonderfully elegant ſituation in which I found them. This diſcovery was afterwards confirmed by all the other tubercles, and their internal ſubſtances. On my firſt obſerving theſe ſurpriſing changes, without knowing the ends which Nature intended to anſwer by them, I looked upon the whole as a moſt inexplicable riddle; as did likewiſe the ingenious perſons then in my company: for our walk was made merely with a view of regaling ourſelves, together with a contemplation of the ſtupenduous miracles of the Univerſal Parent.

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* The Worms found in tubercles of leaves, and other parts of plants, are all owing to the eggs of winged inſects. Their parents are of three kinds: 1. Butterflies. 2. Beetles. 3. Flies. We may know, at ſight, to which of theſe kinds any Worm belongs by its form. If it have no feet or legs, it is the Maggot of a Fly. If it have ſix legs, and no more, it is produced from a Beetle, and will be changed to one. If it have more legs than this number, it is a Caterpillar in miniature, and will change to a Butterfly or Moth.

We find in nature many other things, which agree and correſpond with what I have been juſt now relating. The ſeeds of apples and pears, buried within the fleſh of their reſpective fruits, fall off, little by little, from their coats and cups. The ſame thing is obſervable in the kernels of filberts when they grow dry, and even in the nut itſelf or filbert, which at laſt drops from its cup. But what is altogether ſingular and uncommon, in the tubercle now under conſideration, is, that this ſubſtance, which ſeparates from it, and lies looſe within its body, ſhould contain a living Worm.

When theſe ſubſtances, in conſequence of the hollow occaſioned in the tubercle by a large evaporation, have newly become looſed from it, their circumference is ſomewhat rough and uneven; but as it dries, it grows even and ſmooth to the naked eyes: but the microſcope always diſcovers on the ſurface the remains of the former ruggedneſs, Tab. XLV. Fig. xv. *g*. In the ſame manner the ſpot, at which this ſubſtance received its nouriſhment, never entirely diſappears; but remains diſcernible to the laſt, in the form of a little cicatrix or ſcar, *h*.

The ſubſtance of theſe internal nodules is at firſt ſoft and tender; but it afterwards hardens and dries up, and aſſumes a browniſh red colour, which it never afterwards loſes; ſo that, when viewed within the hollow of its green tubercle, it affords a moſt pleaſing ſpectacle. When thoroughly dried, it is of a pretty compact and firm texture; and in reſpect to its coat or cruſt, it greatly reſembles the rind of a cheſnut, only this laſt is much thicker. But neither theſe ſubſtances, nor the Worms they contain, are all of the ſame ſize.

Likewiſe the number of theſe contained within the tubercles, varies greatly. In ſingle tubercles, every one lies by itſelf in its own particular hollow; but it is the reverſe in the double or more compoſed tubercles. Sometimes alſo, though three or four tubercles grow in one, all their inner ſubſtances have notwithſtanding each its own little cell, ſeparated by a kind of diaphragm or diviſion. The ſpots on which theſe ſubſtances grow within the tubercles, is generally a little moiſt or damp, which keeps them from rolling about. The cavities alſo of the tubercles differ in ſize, which I attribute to the tubercles themſelves having been ſome bigger than others, or to their having been dried up in different degrees. But, in general, there is found only one detached ſubſtance in every tubercle.

On opening one of theſe ſubſtances, that I had taken out of its tubercle, I found in it a living Worm, compoſed of many rings, as I have repreſented it, larger than nature, on the middle of the Oak-leaf, Tab. XLV. Fig. xii. *m*. The figure of this Worm was oblong, and its colour white. On its back appeared a gray ſtreak, approaching to black; which I afterwards, on diſſecting the Worm, found to be no other than one of its inteſtines, which appeared through its tranſparent ſkin, and owed its colour to the half-digeſted food which it contained. In other Worms this ſtreak was ſometimes brown, ſometimes red, yellow, or green, owing to the cauſe already aſſigned. This little Worm lay in its bean-like ſubſtance in the form of a creſcent, quite free and looſe on every ſide. I could not even diſcover in it any umbilical veſſels, or other connecting filaments, by which, according to the vulgar opinion, it might have drawn in its food. It moved and turned itſelf about at pleaſure in this little habitation, being very vigorous and lively. There appeared no excrements in the cell, nor yet the leaſt opening by which it could empty them. The hollows of the tubercles were equally free from any foulneſs of that kind: every place was perfectly neat and clean.

Nevertheleſs I ſhall not deny that this little inſect received nouriſhment within its covering, ſince the contrary is plainly ſeen from the altered food which appeared in its inteſtines, in the form of excrements. Hence I conclude, as a certainty, that this Worm ſubſiſted on the juices of the Oak-leaf, which were conveyed into the cavity of the ſubſtance by its ſtalk, and that it took in theſe juices with its mouth. As this aliment, no doubt, is of the moſt refined kind, there is the leſs reaſon to wonder at the Worm's not voiding any excrements, in conſequence of its uſing ſo fine a nouriſhment. On the contrary, retaining within its body the little that was ſecreted, till an opportunity offered of diſcharging it all together, when it ſhould be turned to a Fly in due courſe of time, and freed from its confinement. It is common with ſeveral inſects, produced from Nymphs and Chryſalides, to evacuate their excrements very copiouſly, within the firſt quarter of an hour after their appearing in the Fly-ſtate. Nor is there any reaſon to wonder at a creature's being able to grow without diſcharging any excrements, ſince new-born Lambs and Calves furniſh us daily inſtances of this kind. Theſe animals never void any excrements at the anus, till they are dropped from their mothers *.

I think it probable that the ſubſtance of the tubercles does not begin to dry up, till the encloſed Worm, having attained the full term of its growth, becomes mature and ready for the Nymph-ſtate; and even at this time, the lower part of the ſubſtance ſtill continues moiſt, ſo that the encloſed inſect may, at this period, alſo draw nouriſhment through it, from the aſcending juices of the tree, in caſe it ſhould happen to require any. Thus we have another inſtance of God's all-ſeeing providence, which, with ſo much goodneſs, watches inceſſantly over his creatures; and this inſtance is the more ſtriking, as the lower part of the bean-like ſubſtance grows looſer and drier by degrees, on the Worm's actually entering into the Nymph-ſtate; ſo that the moiſture I have been ſpeaking of, begins little by little to dry away, when the time approaches for this Nymph to appear abroad in the Fly-form. Sometimes indeed the detached ſubſtances, at this period, are found quite looſe in the cavities of their tubercles.

One of theſe Worms, which I had extracted from its bean-like ſubſtance, lived, notwithſtanding, from the fifth of June to the fifth of July. When the Worm has received ſufficient nouriſhment, it draws the rings of its body cloſer to each other, Tab. XLV. Fig. XVI. It after this caſts a delicate ſkin, and at length aſſumes the form of a Nymph, which is at firſt white all over, but grows blacker and blacker by degrees, in the ſame proportion as the encloſed limbs of the future Fly acquire ſufficient ſtrength to expand and produce themſelves. At this time, there very plainly appear on the Nymph's head, two reticulated or net-like eyes, Tab. XLV. Fig. XVII. *a a*, and underneath in the thorax, the two teeth, which were before diſcernible in the Worm. Along the body lie the antennæ, *b b*, and between them the ſix legs, and the wings neatly folded up. The rings of the body ſhow themſelves very diſtinctly in the lower part, *c*. I refer this Nymph to the firſt mode of the third order of natural mutations, as it clearly repreſents the limbs of the future Fly, in the ſame manner with the Nymph of the Ant.

The two figures I give of this Nymph repreſent it, one of its natural ſize, Fig. XVIII. the other as it appeared through the microſcope, Fig. XIX. It is divided into the head, breaſt and body. The eyes are ſeated in the head, and before them are placed two moderately long antennæ, *a a*. The breaſt bears four wings, *b b*; the upper pair, which are the largeſt, are ſtretched over the body; to the under part of the breaſt, are articulated ſix red legs, each armed at its extremity with two claws, *c c*. The belly of the females is thick, ſwollen, or diſtended; but it terminates in a ſharp point, *d*, which perhaps the creature makes uſe of as a weapon, to bore the Oak leaf, and afterwards as a channel to convey the eggs into the hole made in that manner. The ſurface of the body is ſmooth all over, as if poliſhed, and is of a ſhining deep black, which gives the Worm a pretty appearance. Theſe Flies broke from their confinement the 28th of June; but I diſſected none of them, ſo that I can ſay nothing of their eggs, or of their genital parts.

We are now to conſider another wonder, equal to any of thoſe I have yet related; and this is the ſingular and uncommon manner in which the all-wiſe, and all-powerful Architect has provided for the delivery of theſe Flies, without their meeting with any oppoſition. At the time the Worm has attained the Nymph-form, the encloſing tubercle begins to grow thinner and thinner by degrees, at a certain determinate and ſelect ſpot. This circumſtance I have endeavoured to repreſent in a tubercle, where I found two detached ſubſtances, Fig. XX. *i i*; nor is Nature content with only reducing the thickneſs of the tubercle in this manner; but ſhe likewiſe ordains things, ſo that it dries up and hardens in the ſame place, in order to make the perforation of it, by the teeth of the Fly, eaſier than it otherwiſe would be. The little priſoner, on its becoming a Fly, firſt gnaws through the inner ſubſtance, and then through the tubercle itſelf, a round hole, Tab. XLV. Fig. XII. *k*, juſt large enough to afford it a free paſſage to its new element.

We may know of a certainty, when theſe inſects are about to turn to Flies; for the dry ſpots at which the Flies are to make their way, appear very obviouſly on the ſurface of the tubercles, *l l*. On inſpecting theſe tubercles again, a few days after the 28th of June, I found many of them perforated, and that the Flies bred in them had made their eſcape, ſo that nothing remained in them but the detached ſubſtances, which were likewiſe perforated. The tubercles wrinkle and wither away, for the moſt part, on their inhabitants quitting them. Theſe wonders all return with the ſucceeding year, and thus call upon us without ceaſing, to publiſh the praiſes of their Author, who has openly manifeſted Himſelf in all his creatures, and has given to man alone, amongſt all ſublunary beings, the faculty of knowing Him. In what a bad light therefore muſt thoſe appear, who, unaccountably blinded by their ignorance, dare to oppoſe the exiſtence of that all-watchful and adorable Providence, by fooliſh arguments! Behaving in this manner, and working their own deſtruction, they debaſe themſelves below the rank even of beaſts, and deſerve to be conſidered as monſters in the nature of things.

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* Beſide thoſe Worms which proceed from eggs let into the ſubſtance of the leaf by the parent Fly, there are ſome, both of the Fly and Butterfly kind, which only drop their eggs upon the ſurface of the leaf, and faſten it on by a glutinous matter. The Worms and Caterpillars hatched from theſe, the moment they burſt from the egg, make their way through the outer coat of the leaf, and get into the ſubſtance. They thus live under cover till they change.

Of certain Worms that feed within the ſpongy excreſcence of the Dog-roſe.

THE excreſcence of the Dog-roſe, as to its external appearance, is not altogether unlike that of the Oak repreſented in Fig. VI. of this plate, though it is not of a woolly, but on the contrary, of a ſpungy ſubſtance, in ſo much that it may, with great propriety, be called the ſpunge of this ſhrub. The colour, when dried, is a blackiſh gray; and in the ſame ſtate, the ſurface of it is full of little cavities and prominencies, Fig. IX. *aa.* It grows as the other, at the extremities of the branches, where it ſtands upon the center, juſt as the bud of the Roſe does upon its ſtalk *b.* On opening this excreſcence, we find in it a great many cells, Fig. X. *c,* full of little white Worms of different ſizes and ages. Theſe Worms aſſume, by degrees, the Nymph-form, in the ſame manner with all the Worms living in excreſcences, that I have hitherto mentioned; and under this form they moſt manifeſtly exhibit the limbs of the future Fly: this happens about the end of ſummer.

I had the pleaſure of obſerving two ſpecies of Flies iſſue out of theſe ſpunges, thro' holes they had made in them for that purpoſe. The firſt ſpecies was not unlike the Flies that had been produced, at my houſe, from the tubercles of the Oak, only, that they had ſomewhat thicker bodies, Tab. XLV. Fig. XI. *d,* with black eyes, and all the reſt of them was of a rediſh brown colour. The other ſpecies *e* were of the Biſetæus kind, or had two hairs at the tail, though this character was peculiar to the males. They had likewiſe, in common with the firſt ſpecies, four wings and ſix red legs. Their bodies were oblong; and their heads, which hung to the thorax by a very ſlender neck, were furniſhed with a pair of rediſh eyes. Their bodies all over ſhone like thoſe of the Cantharides, or Spaniſh Flies, with a gilded green, ſo as to afford a very entertaining ſpectacle. Theſe Flies did not all appear abroad at the ſame time, but were employed for ſeveral days ſucceſſively in making themſelves openings in their habitations: this they effected by gnawing the ſpungy ſubſtance with their teeth, into a great variety of holes and cavities, Fig. IX. *f.*

A careful and exact obſervation which I made on the tenth of July, 1674, on the black Poplar, in preſence of the principal magiſtrate of Nieuwenrode, and his lady; both very curious in examining the natural wonders of the creation.

THOUGH all the works of the Almighty are wonderful, we may obſerve, that ſome publiſh his praiſes more manifeſtly than others. This appears moſt eminently in the various organs of generations beſtowed upon animals, and the different manner in which they uſe them; for ſome declare, by evident and intelligible characters, the power and contrivance of the great Architect, whereas others repreſent it by marks that are ſomewhat obſcure and myſterious.

On the tenth of July, 1674, as we were going in a chariot to Scheveling, we ſaw ſome red fruit like Cherries hanging from the leaves of the Poplar-tree, in ſuch numbers, that they could not but ſtrike the eyes of all that paſſed by. When we viewed them near, it appeared to us, that they were ſo many rough tubercles, or extuberances, on the leaves of thoſe trees, Tab. XLV. Fig. XXI. *a,* each of which, when opened, ſhewed a great number of living inſects, to the amount of 60 or 70. Thoſe warts, or protuberances, which projected above the ſurface of the external coat of the leaves, were ſituated exactly under the middle of the nerves or ribs; ſo that theſe nerves paſſed *b* over them; being ſometimes a little higher, and ſometimes lower, according as the warts themſelves projected, more or leſs, without any order from the leaf. Two warts were likewiſe ſometimes found, but very ſeldom, on the ſame leaf. Their ſize greatly differed; ſome of them, as if young, were ſmaller; others larger and more ſwollen; a third kind alſo grew ſtill larger and higher than all the others. When we firſt ſaw theſe tubercles, we thought they were every way ſhut up or incloſed: but upon a more accurate examination, we found, that each of them had, on the inſide of the leaf, where they were ſmooth, an orifice *c* ſomewhat long, thro' which the inſect paſſed at pleaſure.

It is worth notice, that the leaf always ſwelled under its largeſt nerve, which it conſtantly elevated; and likewiſe, that this tumor was only found about the nerve, and in the middle of the leaf. The reaſon of theſe circumſtances ſeemed to us to conſiſt in this; that the eggs of the inſect-inhabitants had been impreſſed on that place only, and that the nutritious juice of the leaf was for the moſt part conveyed thither. Thus it might eaſily happen, that the leaf might be there increaſed and inflated by the nutritious juice accumulated by the irritation which had been produced by the lodging of the eggs in the ſubſtance. And hence alſo we obſerved plainly, that the whole wart on the leaf was nothing elſe but a larger dilatation and expanſion of the leaf itſelf; which cauſed the nerve, puſhed out at the ſame time, to be twiſted into various bendings and windings, which were very conſiderable *dd* in ſome of them.

It deſerved great conſideration to obſerve how regularly all theſe things are done. For when the leaf is newly ſtruck and begins to ſwell, it firſt grows yellow, and thence inſenſibly red, and is at length expanded like a bag, or a hollowed Cherry. In the mean time, the two edges of this extuberance grow ſo exactly oppoſite to each other on the inſide of the leaf, and are, as it were, ſo united together, that the opening, or chink can ſcarce be perceived. This is regularly appointed in that manner by the Almighty, in the nature of things, leſt the eggs or the young Worms ſhould fall out of this their cells, or lodgings, or ſhould creep out before they have attained their full perfection, and are become able to fly. We have now ſaid enough of the external form of theſe tubercles.

When we afterwards opened them, we found in the inſide the following very obſervable circumſtances: in ſome we ſaw Flies full grown; in others, Worms with ſix feet, which were real Nymphs of the ſecond order; and alſo ſome Worms, which, not yet exhibiting the limbs of a Nymph, were only in their firſt growth. We alſo diſcovered there a downy white ſubſtance, and ſome tough fluids, which ſeemed to be encloſed in the membrane.

To treat of each of theſe in their order, I ſhall firſt obſerve, that we found the inner ſurface of theſe warts more ſmooth and flat, than the outward. We thought the reaſon of this difference was, that in the external ſurface of the warts, the ſmaller nerves, which are there diſtributed thro' the leaf, were dilated and extended with the reſt. As to the paleneſs of the colour, we conceived, that the reaſon of it conſiſted in this, that the whole inner ſurface appeared ſprinkled, as it were, with meal and ſmall white grains of bran formed like down. From whence this downy matter draws its origin, we ſhall examine preſently. We ſometimes obſerved ſomething, tho' but little, and that not frequently, of a roughneſs in the cavities of the warts: but whether the cauſe of this was, that the old Flies, remaining there for ſome time, had ſcratched the ſurface with the claws on their feet, we could not certainly affirm.

The ſmalleſt Worms we found within theſe warts, were each divided, like perfect Flies, into the head, thorax and belly, Tab. XLV. Fig. XXII. In the head were ſeen two eyes and two antennæ. To the lower part of the thorax ſix legs were articulated. The reſt of the body was ſomewhat ſhort. They appeared to the naked eye of an azure or fine blue, but greeniſh under the microſcope. They caſt a ſkin in like manner as the other ſpecies of Worms. They alſo moved very quick, and were much more vigorous than the larger Worms, or than thoſe that were already changed into Flies.

What deſerves moſt obſervation in theſe little inſects, is a heap of flocks or down, which each very beautifully and admirably carries *e* on the hinder extremity of its body. Whether that down grows out of the very body of the inſect; which indeed is very likely, or whether it be produced from the tubercle or wart, and afterwards is lodged in the hinder part of the body of the Worm, we could by no means diſcover; tho' we were moſt inclined to think, that the down grew from the body of the inſect, becauſe we no where ſaw it ſticking to the bodies of the more mature ones.

In certain Worms, with ſoft bodies, that live expoſed to the ſun upon the leaves of the Lilies, I have obſerved, that they heap together all their excrements on the hinder-part of their body.

In others that lived among the leaves of Thiſtles, I have obſerved two ſtiff briſtly hairs ſtanding in the hinder-part of the body; on which was always fixed the ſkin which the inſect had caſt off, together with ſome excrements. Thus they lie under their ſkin, as under a pent-houſe, free from the ſun's heat, and walk up and down with it among the leaves. The firſt ſpecies of theſe Worms, at length, changes into a Beetle, of an orange red colour, with black horns and legs; but the other into a large Tortoiſe-beetle, in like manner, with black legs and a black body. Theſe two very extraordinary contrivances do not much differ, with reſpect to the down, from that which the inſect, whereof we here treat, carries on the hinder part of the body. We may likewiſe ſee from hence what miſeries all creatures are ſubject to in this vale of filth and calamities, finiſhing their lives continually under unhappineſs and misfortunes.

The whole inner cavity of the wart, as I have already mentioned, is ſet as it were, or rather ſprinkled over, with that farinaceous down. And this, doubtleſs proceeds from the exuviæ, which the inſect contained in it has caſt off. At the time they caſt the ſkin and this down together, they diffuſe it every where about by running up and down. This downy ſubſtance is very elegantly divided into branches, and greatly reſembles that ſpecies of nitre which riſes out of walls newly built in ſome parts of Holland: when viewed with a microſcope, it ſeems like the ſmaller or branched moſs of trees.

As to the food of theſe Worms, it is very hard to demonſtrate what it is: however, it is very certain, that they are nouriſhed within the cavity of their warts. Probably, that white, tenacious, and glutinous moiſture which I have before ſhewn to be ſecreted within the warts. Hence, that humour is ſo admirably ordered by the all-wiſe Creator, that it never flows away, nor does it wet, nor can it ſuffocate theſe little creatures. As it is ropy and clammy, the down immediately adheres to it, and performs the buſineſs of a membrane or bag, in which, as in a cloſe veſſel with a ſpout, it lies encloſed, and cannot run out of it.

I compare them to thoſe cloſe veſſels, becauſe there are ſome of theſe bags of that figure, Tab. XLV. Fig. XXIII. *f.* and by means of a hollow footſtalk, are fixed to the ſurface of the wart, where the humours, juſt now deſcribed, probably flows out of that excreſcence. Therefore, this is probably the real and only uſe the ſaid down is of to theſe warts, and to the little creatures, it ſerves to confine the moiſture. When this moiſture is conſumed, the downy integuments, which ſurrounded it outwardly, become curled *g* into each other like preſſed flocks of cotton; and therefore ſeveral ſuch downy cluſters are found gathered together in the warts.

The bags juſt now mentioned, containing a fluid, are all furniſhed with a petioli, or footſtalk, by means of which they adhere to the inner ſurface of the tubercle: but whether that fluid be the real aliment with which the Worms are nouriſhed, according to my opinion, or whether they are there fed with ſome other matter, has not hitherto appeared to us from experience. But this is certain, that theſe Worms have neither a trunk, nor any teeth. Nature hath given them only an acute and delicate converging beak, not unlike that of the Cicada, which ſucks the dew: by this beak they can penetrate eaſily enough thro' the downy coat of their bags, and ſuck the moiſture before deſcribed. But whether theſe creatures do really nouriſh themſelves in this manner, or not, I cannot yet affirm, tho' it is very probable.

We poured a ſmall drop of water into the cavity of theſe warts; and it was immediately covered round with that farinaceous down, and was deprived of its fluidity to ſuch a degree, that when it was afterwards ſhaken on dry paper, it did not wet it, but ſlipt and rolled over it, and did not ſtick to it: this was a very agreeable ſight.

There is not ſuch a great quantity of that down about the largeſt, as about the ſmalleſt Worms. On theſe indeed there grew four buds or rudiments of coverings of legs, on each ſide near the ſhoulder-blades. I have repreſented them *hh* on each ſide of the thorax, above the hinder legs. The principal caſes, or firſt buds of the limbs are, in reality, a kind of covers, in which the wings lie folded up. Therefore, theſe creatures may then be properly called Nymphs belonging to our ſecond order of natural tranſmutations; for in that order, the inſects do not at all loſe their motion during the time whilſt they are changing into Nymphs; but on the contrary, walk, ſtand, eat, and move about, until they change their skin; and having at length caſt their exuviæ, they aſſume, as it were, another ſtructure, and acquire only wings. This muſt be well obſerved. I would likewiſe have it remembered, that I have ranked theſe Nymphs in the ſecond order, becauſe they perform their change in ſo obſcure a manner, in the warts of the leaves.

Theſe Nymphs, which are to change, caſt a very fine skin or integument, which is left in the cavity of the wart *. When this is caſt, they acquire, Fig. XXV. the form of delicate ſmall Flies, with four wings. Theſe Flies are of a blackiſh colour, except the membranaceous wings, which have brown nerves, and elſewhere approach ſomewhat to red. The limbs, and other parts, that is, the head, thorax, abdomen, antennæ, eyes, legs, and the reſt, may be now ſeen much more diſtinctly in the inſect, now perfectly mature, than when it appeared in the form of a ſix-footed Worm.

The horns appear to be divided into ſix joints, and are very beautiful; they are compoſed, as it were, of grape-ſtones, or are like a ſmall piece of cinnamon, incruſtated or rough-caſt with ſugar. The eyes are conſiderably large, and reticulated; they appear very diſtinctly when the creature lies on its back. The beak is cloſely applied to the lower part of the thorax, and is there ſeen extended downwards between the firſt pair of legs, juſt in the ſame manner as the Cicada. The wings, beſides their nerves, and the veſſels, wherewith they are elegantly diſtinguiſhed, exhibit two oblong black ſpots, with which they are ornamented.

This creature flies very ſlow; indeed it does not move with ſo much ſwiftneſs as the ſmall Worm, out of which it is produced. I have not yet diſcovered, by diſſection, the difference between the male and female; nor have I ever ſeen the eggs of this Fly. I am inclined, however, to think, that they are lodged by the parent, on the inner coat of the Poplar-leaf: and that the wart or tubercle here deſcribed, is afterwards formed there by nature, in order to hatch and nouriſh them, and to keep them in ſafety. But how all theſe things are performed, we can yet only conjecture: ſince they muſt be known, not by reaſoning, but from ſolid experiments. I ſhall here therefore furl my ſails, and in amazement, celebrate the great Creator, who hath hidden ſo many, and ſuch inexhauſtible natural and important miracles, full of true knowledge and erudition, in his creatures; ſo that the air, the water, and the earth; the plants alſo, that vegetate therein, abound with them; and all vegetables and animals, however ſmall, proclaim the glory of the Supreme Being.

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* The modern term for all Worms bred from the eggs of winged inſects in tubercles, or parts of vegetables, is Aſcarides. Reaumer is the author who eſtabliſhed this. Some of them burrow deeper, others very ſlightly; all get under cover of the upper membrane. The manner of their getting through it, when their parent inſects have lodged them on the ſurface, is various; the Caterpillar kind eat their way; the Worms of Beetles get in by breaking the ſurface with blows of their head.

Of the footleſs Worm of Cabbage-leaves, which properly belongs to the fourth order or claſs of natural changes.

ON the 15th of Auguſt, I found on Cabbage leaves ſeveral footleſs Worms, and ſome of their Nymphs. The body of the Worms, was in the fore part ſomewhat pointed, but in the hinder part a little thicker, Tab. XLV. Fig. xxvi. They were alſo divided into annular ſegments, which appeared in the ſkin like ſo many ſmall inciſions. They were of a pale green colour; but they appeared variegated, by means of certain white viſcera, which were ſeen through the tranſparent ſkin. This creature was by nature very ſlow and heavy, though, when touched, it ſhewed greater agility and ſprightlineſs. Whether it uſes Cabbage leaves for food, or hunts there after ſome green little ſix-footed inſects, which are at length changed into Nymphs of the ſecond order, and from the latter into Flies; I have not accurately inveſtigated: I know ſome are of this laſt opinion. This Worm uſually ſtretches aloft the fore part of its body, in the ſame manner as an Elephant does its trunk, when it firſt begins to move and go forward. Therefore, I do not doubt, but it is the very creature which Goedaert deſcribed, Exper. XI. part II.

When this Worm hath at length fed enough, and its internal parts have acquired ſufficient ſtrength to put on the form of a Nymph, it is then changed, Tab. XLV. Fig. xxvii. and xxviii. into a real Nymph of the fourth order; which change is performed in the following manner: We firſt obſerve, that the Worm, before it caſts any ſkin, becomes inſenſibly ſhorter; that its head is entirely contracted on the inſide, and at the ſame time it becomes thicker; but the hinder part, by degrees, grows ſmaller, and more ſlender, the body thus loſes its former figure. For the blood, and all the fluids, are propelled forward to the new parts, which are now increaſed, and ſwollen under the Worm's uncaſt ſkin, and appear divided into the head, eyes, thorax, legs, wings, and body: this may be clearly ſeen, if this Nymph be artificially ſtript of its yet uncaſt ſkin. One may likewiſe ſee the ſeveral particulars beforementioned through the ſkin itſelf; when the Nymph, being ſome days old, begins to acquire its proper colours.

As the colour of the Nymph, on the change is white, and is afterwards altered into a green, mixed with a pellucid white; the red eyes in the head appear, Fig. xxviii. *a a*, gradually through the tranſparent ſkin. The ſame thing holds, *b*, in regard to the thorax, which exhibits ſome pellucid hairs on its ſurface. In the hinder part of the body, the abdomen is ſeen through the ſkin, divided *c c c* into ſeveral rings, which are likewiſe ſet with ſmall hairs. On one ſide of the body is ſeen a wing *d* ſomewhat pellucid. Towards the hinder parts, and near the tail a curled little veſſel, Tab. XLV. Fig. xxviii. *e*, which indeed ſeemed to me to be a pulmonary tube rolled out.

When this Nymph is grown older, and at length becomes all coloured, then theſe parts appear moſt diſtinctly, if the ſkin be taken off: this will be evident from the magnified figure thereof, which I have given here. In this are diſcovered, Fig. xxix. *a*, the Nymph's reticulated eyes; above and between which are two ſhort *b* horns. The proboſcis or trunk is laid along the breaſt *c*, and near it, the firſt and ſecond pair of the fore legs, are ſeen to be beautifully diſpoſed. On each ſide of the breaſt lie the folded wings, *d d*, and under them the laſt pair of legs, *e*. What deſerved the greateſt notice in this creature was, that the extremities of the genital parts, were placed, *f f*, as it were, beyond the rings of the body, and terminated in ſhaggy points: which are at length drawn into the body, when the Nymph puts on the form of a Fly.

This Nymph is therefore a very uncommon one; and though properly referred to the fourth order, yet it undergoes conſiderable changes, and exhibits no more of its former ſhape than the ſkin only, which it does not caſt, but retains. The reaſon why this Nymph ſo much differs from others, of the ſame order is, becauſe it is inveſted with a tender and thin ſkin, which obſequiouſly accommodates itſelf to the growing and protuberant limbs within. All this I have explained in the preceding pages, where I treated expreſly of the nature of the fourth order. We muſt further obſerve, that this Worm, when changing, is not diſengaged from the Cabbage leaf, as is the caſe in regard to many other inſects: on the contrary, it firſt glues itſelf thereto by a viſcous matter, which appears Fig. xxviii. *f f*, like a thin membrane on the leaf.

The Worm having had this form ſixteen or ſeventeen days, the hidden Nymph then breaks open, and caſts off the outward ſkin, and at the ſame time draws a thin film off from the whole body, and from all the limbs, which is left on the inſide in the old ſkin. Thus the Nymph appears, Fig. xxx. at length under the form of a Fly. The young Fly is much ſmaller at firſt, than in a quarter of an hour afterwards; for its parts are in that time inſenſibly extended, particularly about the head and belly, ſo that the Fly becomes almoſt twice as large, in ſo ſhort a time after it is produced; after which it never increaſes any more. If any one would know the reaſon how the body of this Fly is ſo remarkably diſtended, it will appear, on examination, that it conſiſts in reſpiration, which fills all the pulmonary tubes, and pneumatic bladders with air; and theſe, on the other hand, expand the hitherto ſoft body of the creature, and give it a firm and durable figure.

This Fly is beautifully divided into the head, thorax and abdomen, and has ſix legs and two wings. Behind theſe, two little parts are obſerved to be fixed to the thorax, ſupported, as it were, by two fine footſtalks, with their extremities headed; ſo that they reſemble two little hammers, which, the Fly ſtriking againſt the wings, forms the noiſe peculiar to it. The eyes are ruddy, the thorax is greeniſh; the abdomen, on the contrary, is yellowiſh, and is variegated with blackiſh hairy wreaths.

I have often ſeen inſtead of the Fly, which is commonly produced from the Worm before deſcribed, eight other Flies iſſuing out of its Nymph, which had indeed drawn their origin from the Worms that feed on the internal parts of that Nymph, and were changed within it, into ſo many ſmall Nymphs. When theſe little Nymphs had at length grown into Flies, they flew out, after piercing the ſkin of the larger Nymph. Theſe Flies had each ſix red legs, four wings, and a body that glittered with a golden and very lively green, excelling the light of the ſun's rays.

Of the Worms called Moths.

THOUGH the Moth is a very common creature, yet few know it; for it lies hid, and does not exhibit itſelf to open view; for that reaſon it is the more miſchievous. Moths are in reality Vermicles, or Worms that live in woven cells, at all times, except when they build their neſts, in wool, ſkins, or birds feathers: in thoſe caſes, they uſually build themſelves irregular cells, becauſe they have both the habitation and food, which they then irregularly grind with their teeth, always ready.

They build their habitations very artificially, ſo that they are always larger in the middle, and narrower, Tab. XLV. Fig. XXXI. *a*, on each ſide, where the paſſage is: and that ſtructure does this ſervice to the Moth, that it can the more conveniently turn itſelf in the middle of its habitation, and go out through either orifice when neceſſary. It is alſo obſerved ſometimes, that the Moth ſpins a fine thread, eſpecially when it creeps near the walls and beams of houſes, ſeeking its food there; for this is of various kinds. In that caſe it forms this thread, to prevent falling down, when it ceaſes working, and goes into its cell; for at that time only it hangs ſuſpended, *b*, from the thread. I have likewiſe often ſeen, that the Moth ſpins this thread, when the anterior or forepart of its body has firſt crept *c* out of its little caſe, and endeavoured to fix itſelf ſomewhere by means of it: but when the creature was afterwards inclined to proceed further, it broke this thread, and going out of either opening of its cell, fixed it again in another place: and when this is done againſt a beam or wall, it forms a very beautiful ſight.

In order to deſcribe more particularly the little Moth, which I here exhibit in its natural ſize; I muſt obſerve, that with reſpect to its ſtructure, it is not unlike a ſmall Caterpillar. It has a glittering raven-black head, in which its eyes, and two ſharp-pointed teeth are placed. The reſt of the body is of a whitiſh or fleſhy colour. Six legs are fixed to the breaſt, eight in the middle of the body; and two are ſituated in the extremity of the abdomen under the tail. The Moth, however, never creeps out of its habitation, but by the ſix fore feet; by the help of the other ten, it lies fixed in its little caſe: that is, when that Worm advances forward with its ſix fore feet, then it takes hold of its cell within, with the others: and this too is the reaſon, why it always carries its caſe with it, not differing much in this reſpect from tortoiſes.

But the Moth, while growing, always entirely forſakes its caſe, when it is become too little for its body, being on account of the increaſe of bulk, obliged to form itſelf an intire new cell, into which, as into a new habitation, it afterwards repairs, after leaving the old one. The Moth never undertakes that office, until compelled by neceſſity; that is, when the old habitation is not ſufficient to cover its body. The inſtinct and prudence of this creature, are moſt evident from hence, that in preparing an habitation big enough for its body, it does not deſire large and magnificent buildings, which the folly of mankind ſo much ſeeks after. Man, whom God created with an upright countenance, over-burthens himſelf with heavy labour, nay, he ſometimes periſhes under a multitude of houſes and apartments; the tapeſtry and hangings of which are expoſed to this Moth, only to be gnawed and eaten for food.

When the Moth leaves its former caſe, in order to form for itſelf an entire new cell, it does not get for that purpoſe beams of cedar, nor Italian marble: it prudently and ingeniouſly makes uſe of that matter which it finds near about it. When it lives in green cloth, it makes the outſide of its whole cell of a green matter; that is, the wool which it bites off the cloth, and artificially interweaves with its web: it lives on the ſame ſubſtance, and uſes it for food; and therefore its excrements are alſo green. It does the ſame when it reſts or pitches on white, yellow, red, blue or black cloth; or when it finds in its way any coverlid, garment, or cap, that lies unuſed and neglected in a corner. If it can find none of theſe materials, it remains in old old houſes, armories, repoſitories, and even in ſtone walls; it eats duſt and Spiders-webs, whereof it makes an habitation in the ſame manner. I have, on theſe occaſions, ſeen it interweave ſmall bits of broken cement with its habitation, in order to make it ſtronger; ſo that this creature makes every ſoil its country, and yielding to neceſſity, leads a happy life amidſt the miſeries to which we are ſubject.

The Moth never brings any foreign matter into the inner ſurface of its cell, where its body lies; conſequently nothing elſe is obſerved there, only the Moth's proper web, which being of a ſoft, ſmooth, and even texture, ſerves both for a habitation and bed. In this manner that Worm lives, till its parts are increaſed to their due perfection under the ſkin: and at that time, it covers both the orifices of its little caſe, and caſting of its old ſkin within, Tab. XLV. Fig. XXXI. *e*, is changed into a Chryſalis, which is properly referred to the ſecond mode of our third order; becauſe it does not very clearly exhibit the limbs of the inſect to be produced from thence: this is a nocturnal Butterfly, or Moth. When this inſect is firſt changed, all its parts are beautifully white, but they afterwards grow inſenſibly yellowiſh, and at length acquire a faint red, which they finally preſerve. In the head, particularly the eyes, which are ſeen through the ſkin, firſt acquire their colour and perfection; afterwards the whole body finally appears through the ſkin, of the ſame colour with the nocturnal Butterfly, to be produced from thence.

July 13th, the Butterfly appeared, *f*, after it had lain twelve or thirteen days under the form of a Chryſalis, without food or motion, and its tender limbs had, by the evaporation of the ſuperfluous humours, inſenſibly acquired ſufficient ſtrength to break open the outmoſt ſkin. This Butterfly was provided with four wings, ſix legs, two horns, and two black eyes. Its wings and body had many ſuperb ſcaly feathers, which very beautifully adorned the creature with various and agreeable colours. Theſe colours being viewed with a naked eye, reſemble fine flour, and may be eaſily reduced to ſuch a powder with the fingers: and therefore, frail man, as mentioned in ſcripture, is very properly compared to a Moth.

This little creature, the Butterfly, is commonly called a Moth; though it is noxious on no other account, but that it lays thoſe ſpheroidal eggs out of which the real Moths, or eating Worms, are at length produced, in hangings and cloaths, in like manner as the Flies producing Maggots lay theirs in meat, fiſh, cheeſe, and meal. When theſe creatures fly or flutter about, thoſe who would preſerve treaſure from Moths, muſt be careful to keep them from it; for otherwiſe their neglect will be a great hurt to them, and cauſe much loſs and concern. Theſe are the conſequences that commonly attend ſloth and negligence.

When this Moth hath broken out of its woven cell, it is always obſerved, Tab. XLV. Fig. XXXI. *g*, to hang a little out of one extremity of the ſkin, which the Chryſalis had caſt. But if the caſe itſelf be then opened, one may diſtinctly ſee how even and ſmooth it is woven, *h*. I ſhould never finiſh, if I attempted to deſcribe and delineate all the ſpecies of Moths, ſince there is a great number and variety of them. I ſhould think, that what hath been hitherto ſaid is ſufficient, ſo that there is no need of more; for it is eaſy to know a Lion by his paw.

Of certain Worms that, like the Moths, live in cells, feeding on the leaves of Pear-trees, Apple-trees, Plum-trees, and Cherry-trees.

OBSERVATION I.

I Preſerve, in my collection, various and particular ſpecies of theſe Worms, ſome of which form their cells of bits of wood, which they bite off; and hence are properly called Ligni perdæ: but of theſe I ſhall hereafter treat in another place. The firſt ſpecies of thoſe, of which I am to treat here, was ſhewn me on the leaf of a Cherry-tree, by the very experienced and celebrated Dr. Luke Schaght, profeſſor of the Materia Medica in the univerſity of Leyden. I afterwards found it likewiſe on the leaves of the Willow and Alder-tree. The cell which this Worm inhabited was black as pitch, Fig. XXXIII. *a*; and conſiſted of a ſubſtance, as it were, of bark, and woven into wrinkles. Its hinder part was thicker than the fore part, and divided, as it were, into two lobes. Its foremoſt extremity terminated ſomewhat acutely, and out of it crept its inhabitant, carrying this little caſe entire, obliquely on its body; but when the Worm reſted, the caſe ſtood perpendicular on the leaf.

This Worm was, in regard to its ſtructure, ſcarce different from the Moth. When it has eat enough, it fixes itſelf to the leaf, near the opening of its cell, and is changed within it into a Nymph of the firſt mode of our third order, which *b* grows at length into a very beautiful Fly. On the head of this Fly, which is black, are placed two rediſh horns. Its thorax and abdomen are partly red, and partly black. It has four beautiful membranaceous wings, which ſhine like very fine Mother of Pearl; and are likewiſe variegated, nearly in the middle, with two black ſpots. It has moreover ſix red legs, which are divided into joints, each having two claws at its extremity. This creature is alert and ſprightly, and flies very ſwift.

OBSERVATION II.

I Found a ſecond ſpecies of thoſe Worms, which carry their cell with them, on the leaf of the Alder-tree. This creature fed on the inward coat of the leaf, and therefore conſumed it all unto the nerves of that external coat. It does not differ much from the former, except in reſpect of its habitation, which it carries every where on its body: but in this there is a conſiderable difference; that is, it is of the colour of the leaves that fall in autumn, tho' ſome of theſe cells are alſo found of a ſtronger colour. This cell is triangular, Tab. XLV. Fig. XXXIV. *c*, at the upper extremity: it ſwells a little in the middle; but the part that contains the body of the creature, is again contracted, and therefore it is formed like a big-bellied cylinder.

I have ſeen three ſorts of creatures produced from theſe Worms; for as one of theſe ſmall creatures had, according to the ſecond mode of the third order, been changed into a Nymph, which aſſumed the form of the future Butterfly, I at length obſerved a pretty little nocturnal Butterfly or Moth, not much different from the Cloaths-Moth, ſprung *d* out of it. I ſaw a black Fly *e* with two horns, four wings, and ſix legs, produced from another ſimilar Nymph, which however ſhewed before the form of a Fly, according to the firſt ſpecies of the third order. But the moſt ſingular event of all was, ſix or ſeven very ſmall *f* Flies, which, from more tender Worms, had been firſt transformed into Nymphs, iſſued out of another Chryſalis of ſuch a Vermicle as belonged to the ſecond mode of the third order. Whether this be common, and conſtantly happens annually, as is the caſe in other Caterpillars; or whether it be peculiar only to thoſe that inhabit the bright brown cells, in which only I obſerved it, I have not indeed yet learned from experience. And, indeed, what man can perfectly inveſtigate all the changes of parts which happen, even in one creature. I am, indeed, every moment taught by experience, that nature is, in regard to thoſe real cauſes, by which animals and their parts increaſe, in many particulars, perfectly impenetrable to man. However, a firm and conſtant diligence hath, by degrees, diſcovered to me more than one could eaſily believe; though what we are ignorant of is, and will remain, much greater than all we know. Hence, indeed, we have knowledge of many things; but our ignorance ſtill prevails and predominates.

Of certain Vermicles or Worms, whoſe eggs are lodged in the bags wherein muſk is brought to us.

I Should never make an end, if I attempted even to enumerate all the hidden changes of the Caterpillar and Worm kinds into winged inſects; ſo fruitful and manifold is Nature in her genera and ſpecies! For this reaſon I ſhall only add the following obſervation, and afterwards finiſh this hiſtory of the fourth order with accounts of two Worms which live in tubes, one in the earth, and the other in the water; for the water abounds as much with theſe inſects as the land.

On the 10th of July I found a great many ſmall white Worms, Tab. XLV. Fig. XXXII. in a bag, wherein muſk comes to us. All theſe had a reddiſh brown head, and black teeth. Six legs adhered to the breaſt. The body was covered with fine hairs, ſtanding erect. This muſk-bag was in a little box, not very cloſely ſhut, the bottom of which was covered with white paper, through which theſe Worms penetrated into the wood of the box, by various holes which they gnawed through it. And indeed thoſe holes, which are as conſpicuous in the paper as in the wood, moved the admiration of the perſons who viewed *b* them. As they were bit regularly into a round, oblong, or oval circumference. I further obſerved, that many of theſe Worms made themſelves in their caverns a pretty thick, oval, lemon-coloured web, whereon they had weaved many cotton-threads, after the bag of muſk had been placed in the cotton.

When I opened theſe webs, I found real Nymphs in them, Tab. XLV. Fig. XXXII. *d*, which belonged to the firſt mode of the third order; for each very diſtinctly repreſented the limbs of a future Beetle. Some of theſe Nymphs were very white; but in others, which were older, the eyes were turned black, and the whole Nymph, from white, inſenſibly became tinctured with various colours; and was, at length, changed *e* into a very beautiful little Beetle, after caſting its ſkin. When theſe Beetles have newly caſt their ſkin, in which they appear like Nymphs, they are of a ſnowy white colour: they afterwards grow yellow by degrees, till at laſt they become of a duſky purpliſh hue, and afterwards always continue ſo: ſome of them, however, conſtantly preſerved a colour between yellow and red.

They are diſtinctly divided into the head, thorax, and belly. They have two black eyes in the head, juſt over which project two rediſh horns, thick ſet with fine hairs of the ſame colour. The thorax is likewiſe adorned with yellowiſh hairs, that glitter almoſt like gold, and exhibit ſix hairy legs of the ſame colour with the horns, affixed to its lower region. The caſes or covers of the wings are divided with ribs; and the latter, together with ſeveral little depreſſions, are every where ſet, as it were, with fine hairs. This obtains chiefly about the ſhoulder-blades, and on the hinder part, where theſe caſes or covers are bent, near the extremity of the abdomen; for they have a tuft of whitiſh hairs in the fore and hindermoſt parts. The under wings are membranaceous, and they very expeditiouſly fold themſelves under the ſheaths or caſes with which they are covered, notwithſtanding their being twice the length of the abdomen.

This ſpecies of Beetles may, on account of the conſtruction of the horns, be referred to the flying Capricorn kind. I have ſeen Beetles produced from ſome other ſpecies of Worms, that live on rotten and hollow wood; the horns of which were formed in the ſame manner as the Silkworm Butterflies. The only difference was, that all their diviſions or plates were ſeverally jointed together. This ſtructure formed a very beautiful ſight, and clearly demonſtrated the wiſdom and art of the Creator. This is ſtill more evidently conſpicuous in the Fullo-Beetle, whoſe female is delineated in Mouffet; but it wants thoſe ornaments, which are found in many ſpecies of inſects, peculiar to the males, wherein they are more beautiful than the females.

The Worms here deſcribed feed on birds feathers, and therefore do a great deal of miſchief. They are found in ſeveral places in Holland, and may be reckoned among the ſecond ſpecies of Worms that gnaw fleſh clean from bones; and therefore are very proper to prepare fine ſkeletons.

Of certain Worms which lie in little tubes or cells.

OBSERVATION I.

I Preſerve ſeveral ſpecies of tubes in which Worms live *; but I ſhall not, in this place, deſcribe them all. The firſt which I here exhibit is formed by a Worm, reſembling a Caterpillar; which makes, Tab. XLV. Fig. xxxv. a pyramidal tube or pipe for itſelf, to which it afterwards faſtens, for greater firmneſs, various little parts, bitten off from plants and leaves of trees; ſo that the ſurface of the tube reſembles thoſe chequered works, with which the doors of armories and caſtles were formerly adorned: and with this beautiful cell the Worm walks and goes about, till it is changed into a winged creature, being diſengaged then from the burthen of its houſe and bed, which it was hitherto obliged to carry.

OBSERVATION II.

THE tube, whoſe figure I here add, Fig. xxxvi. to the former, is not leſs beautiful or artificial in its ſtructure. I found it in the ſalt water, on the coaſt of the German ſea. It is inhabited by a tender Worm without feet, having many gold-coloured briſtly hairs in the fore part of its head; by the help of which it can gnaw innumerable grains of ſand, and join them ſo accurately together, that even the moſt nice artiſts muſt be aſtoniſhed at it. The inner ſurface of this tubulated and pyramidal cylinder is ſmooth and equal; but the external part is, on the contrary, uneven. This difference proceeds from hence, that the creature can turn all the plain and poliſhed ſurfaces of the ſand inward, and leave the angulated and rough ſurfaces on the outſide. The figure, by which I repreſent this tube, exhibits only the third part of its natural ſize: it could not be all delineated otherwiſe, for want of room in the plate. I have not yet obſerved what kind of metamorphoſis this inſect undergoes.

It merits great conſideration, what kind of ſaliva or glutinous moiſture that is, by which this Worm can faſten the grains of ſand together in ſuch a manner, that the whole contexture dries and hardens in the ſalt water. I muſt ingenuouſly confeſs, I am doubtful in this as well as many other matters; ſince I can by no means conceive how this piece of art is executed. I have obſerved, that many other aquatic inſects alſo frame a web or covering, under the water; the thread whereof hardens in the midſt of the fluid, in the ſame manner as the Silkworm-webs in the air.

In regard to the other aquatic inſects, I have obſerved, that ſome of them form their cells of ſmall fragments of ſtones; others of larger pieces joined together; ſome of ſnail-ſhells, which they have gathered up and faſtened together; others again are made of pieces of ruſhes, various parts of plants, wood, and other materials: nay, I have ſeen ſome, which, when they were preparing for their change into tne winged ſtate, could weave very heavy ſtones into their cells, and fortify them, as it were, with a lattice-work of maſonry. They dived to the bottom of the water by this means, and, being there free from all danger, they changed and renewed their bodies. God is therefore admirable, wherever he is manifeſted: he hath repreſented his omnipotence and wiſdom in all his creatures; therefore, let him only be honoured and glorified to all eternity.

The End of the Hiſtory of Inſects that inhabit fruits, tubercles, leaves, and the like.

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* The name by which this kind of inſect is generally called, at this time, is Tinea Campeſtris, the Field Moth. Reaumer, who gave them this name, obſerves, that their origin and manner of life are the ſame with thoſe of the common Cloaths Moths; the only difference being, that theſe feed upon moiſt, the other upon dry food.

A par-

A particular treatiſe on the Frog and its young, exhibiting its hiſtory, and comparing it with inſects.

Tab. XLVI.

A Compariſon of the metamorphoſis, and, if I may be allowed the expreſſion, a tranſcretion of the parts, happening in young Frogs, with that obſerved in the Nymphs of inſects.

As, in the preceding ſheets, I have occaſionally, though ſlightly, touched on the likeneſs of the change of limbs in the larger or ſanguiferous animals, to that which inſects undergo; I ſhall here delineate and explain this ſubject more at large, in order to make the knowledge of it diſtinct and clear. For this purpoſe *,

Tab. XLVI. N°. I. exhibits the Frog's real egg, or the Worm of the young Frog, encloſed in its firſt coat. It repreſents a ſmall *a* black globule, ſurrounded *bb* by another globe, conſiſting of a clear, clammy, and glutinous matter. This matter is the real food of the Worm of the Frog, which now lies within, covered as yet with its proper integuments: therefore the Frog's Vermicle or Worm may be conſidered as the yolk, and the food the white of this egg.

N°. II. I lightly expreſs the inveſting coat or integument before mentioned. It is here caſt off *c*, and rolled back *d* to the hinder part of the Frog. It likewiſe appears, in this figure, how much the ſurrounding aliment is now dilated, *eee*. Hence the young Frog is circumſtanced exactly in the ſame manner as all Worms and Caterpillars of each of the four orders are, when they have caſt their firſt coat, or their egg-ſhell; in which I call them Oviform-Nymph-Animals, or Oviform-Nymph-Vermicles, as may be ſeen particularly in the fourth order, where the egg is conſidered.

N°. III. It is delineated to the life how the young Frog, called a Tadpole by authors, ſwims in the middle of its food, and alſo in what manner that food appears in the water like a diſperſed cloud, *fff*. The Vermicle or Worm itſelf is here delineated much larger than it was, when it firſt began to ſwim into its food, immediately after quitting its ſhell, or firſt membranaceous integument. Therefore one may now very diſtinctly ſee its head, breaſt, and body. But becauſe the perſon, who I ſhall deſire to diſtinguiſh theſe parts, ought to have a thorough knowledge of them, thoſe who inveſtigate nature but ſuperficially, look into that globe only for the young Frog's head, though it really comprehends the whole body; as the incomparable Harvey has before juſt obſerved. At the extremity of this young Frog's body is ſeen a long continued tail, Tab. XLVI. N°. III. *h*, by the help of which it ſwims; ſince the Frog is, whilſt it wears that form, a real footleſs Worm, and, in this reſpect, reſembles the feetleſs or apode Vermicles or Worms of the firſt mode in our third order.

Here it muſt be well obſerved, that the young Frogs never conſume their food entirely; which, for that reaſon, is diluted by the imbibed fluid, and gradually attenuated; ſo that, at laſt, it reſembles a little cloud floating in the water. Indeed, that gluy cloud is inſenſibly dilated to ſuch a degree, that it ſeems deſigned for the young Frog as a place to reſt in, when it ſhall think proper: for which reaſon it is likewiſe obſerved, that, when tired with ſwimming, it quickly penetrates into this cloud, and there remains without motion.

And here I ſhall beg leave to obſerve further, that as the inſects which are found in cheeſe, putrified fleſh, and many fruits, and in tubercles, lie ſurrounded with their nouriſhment; ſo, in like manner, the young Frog ſwallows its food, at this time, through its mouth, as they do. There is however this difference, that the young Frog is nouriſhed while it yet lies in the integument or coat of its eggs; and this I could never obſerve with reſpect to any other inſects. The inſects, in general, lie in the coats of their eggs, in the ſame manner as Butterflies do in their Caterpillars, and only increaſe in ſtrength. Therefore, I do not doubt but the young Frog is provided with umbilical veſſels, of which matter I ſhall afterwards treat in its place.

N°. IV. I repreſent how the hinder legs *ii* are obſerved to increaſe in the Tadpole, or young Frog; that is, whilſt they inſenſibly ſpring out of the body, as the cups of flowers from out of their footſtalks, or as the caſes wherein the wings of inſects are at firſt repoſited: ſo that the young Frog is, in this reſpect, very like thoſe little creatures deſcribed under the ſecond order; though it again differs from them, in that it is produced from the egg in form of a footleſs Worm.

I likewiſe obſerve, that about this time the young Frog's fore legs are inſenſibly increaſed and augmented, under the ſkin, in ſuch manner as I have before explained, in regard to the Worms and Caterpillars of the third order. For this reaſon one may likewiſe plainly diſtinguiſh, with the naked eye, the rudiments of the legs, if the ſkin be then opened in that part. And this is likewiſe the caſe in all the Worms and Caterpillars juſt mentioned, as I have occaſionally exhibited in the former tables.

Tab. XLVI. N°. V. I here repreſent, to the life, how all the limbs of the young Frog have at length arrived to perfection, by a ſlow increaſe. The two fore feet are ſeen *k k* ſtill lying under the ſkin; but the two hinder legs project beyond the ſkin, *ll*, though they are, in reality, ſtill inveſted with the ſkin of the Tadpole, which they afterwards are to caſt off. This ſkin is dilated and ſtretched out with the growing feet, as is likewiſe the caſe in injects of the ſecond and third order. Hence it is, that I really very properly give the young Frog, in this form, the appellation of the Frog's Nymph, which it ſeems may be likewiſe referred to the ſecond or third order. But as the young Frog, while it is under this form of a Nymph, ſtill ſeeks its food, and moves about, it therefore approaches much nearer to the inſects of the ſecond order, than to thoſe of the third; for this reaſon, it likewiſe caſts its ſkin in moving and ſwimming, and brings to view its fore legs, then reſembling thoſe of a perfect Frog; though it ſtill, for a long time, keeps its tail, which afterwards ſhrivels up by degrees, and, finally, dries away.

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* There is ſcarce any animal which has the principle of life ſo ſtrong as the Frog. It will continue moving many hours after the guts are taken out. An Eel is celebrated for this ſtrength of life; but the Frog exceeds it greatly. No creature is ſo truly amphibious; for it will live for a length of time equally well on land without water, and abſolutely immerged in water. A Frog has been tied down under water many days, and received no hurt, nor ſuffered any ſeeming inconvenience.

N°. VI. I ſhow how the Frog, having gradually gone through the forms of an Egg, Worm, and Nymph, at length has attained its perfect maturity, and appears fit for propagating its ſpecies, in the ſame manner as inſects and vegetables, and thus is able to continue its generation. It muſt be obſerved here, that the Frog is not abſolutely perfect, or fit for generation, immediately after its metamorphoſis. By no means; for, unleſs I am greatly miſtaken, this creature does not acquire that degree of perfection until two or three years. The Frog, therefore, differs in this double reſpect from the ſanguiferous animals, and from inſects; moſt of which are perfect in one or two hours after their birth, or after their metamorphoſis from Nymphs, and then likewiſe immediately obtain their full ſize and maturity, and at the ſame time become fit for the office of generation. The Frog which I here expreſs, of full age, is the male; as one may very certainly know from thoſe two veſicles, Tab. XLVI. N°. VI. *mm*, which are ſituated behind its eyes, and are never to be found in the female. There is moreover another certain ſign, whereby the male may be diſtinguiſhed from the female; but that I ſhall deſcribe and delineate in a particular hiſtory, which I ſhall ſubjoin to this general account.

Man himſelf compared with inſects, and with the Frog.

IT is evident from comparing the Frogs, as we have juſt now done, with the inſect tribe, how the ſanguiferous animals, or ſuch as have red blood in their veſſels, are, in repect to their changes, like theſe ſmaller creatures. Indeed this likeneſs proceeds ſo far, that it extends under many names, even to man himſelf: for all the works of God ſeem to proclaim, only one foundation of propagation and increaſe.

I firſt obſerve, that it is clearer than the light at noon, that man is, like inſects, produced from a viſible egg, which, after being impregnated, is brought forth: that is, it is by a local motion conveyed out of the ovary through a tube into the uterus, which is the place wherein man, that rational animal, finds his firſt nouriſhment, and repreſents, as it were, a Vermicle or Worm, or, to uſe Harvey's words, a Maggot lying in the egg.

Secondly, The membranes which then inveſt the Infant-Man, are there likewiſe dilated, in order to receive an aqueous humour conveyed from without to the Man-Vermicle. Therefore, the human egg likewiſe reſembles the eggs of inſects, in that the latter dilate, nay, break open their coats, in order to get elſewhere the nouriſhment which they do not find in their egg.

Thirdly, We obſerve, that the Vermicle or Maggot of Man, as well as the Vermicles or Worms of other inſects, have not completely perfect limbs; therefore it is increaſed in ſize, even from the beginning, till its limbs project at length out of the ſkin, and its umbilical cord is divided into two arteries and one vein, which take root in the internal ſurface of the uterus, and conſtitute the placenta, or after-birth.

Fourthly, It is very clearly obſerved, that theſe parts of the Man-Vermicle grow by degrees into a head, thorax, belly, and limbs. In the head, the coloured eyes are very diſtinctly ſeen through the ſkin; but they are more conſpicuous in the beginning than afterwards, when the ſkin becomes thicker; for then they can be no longer ſeen. But it is indeed very admirable to obſerve, how the limbs ſprout about the ſhoulder-blades, and at the lower parts of the body: for, in the beginning, they reſemble the ſmall cups of flowers juſt budding, or the bags and caſes of the parts of inſects; the former encloſing the flowers, and the latter the wings; and then, by degrees, juſt as the legs of Frogs, they grow out of the body, and are divided into joints.

Fifthly, We obſerve further, that all the limbs of the Man-Vermicle, in time, acquire their due perfection, and are ſtrengthened to ſuch a degree, as to be able to break out of the uterus, and to diſengage themſelves from all their integuments. And hence this firſt ſtate of man likewiſe reſembles an inſect, in that it hath, under the form of a Chryſalis or Nymph, acquired all the ſtrength requiſite to change its ſkin, and appear like a perfect creature. Man therefore, as on the point of his birth he does, like inſects, throw off and loſe ſeveral very conſiderable parts, may indeed be deſervedly called, at that time, a Nymph; ſince he then is to caſt off his umbelical veſſels and placenta, together with the ſkin and the amnion.

Sixthly, This tender and new-born creature leaves the uterus, in the ſame manner as the Ephemerus and Libella, that have caſt their skin, and leads a new life, and has a different nouriſhment.

ment. The infant-man, who lived before in the water of the amnion, now breathes the vital air, which ruſhes into his lungs, and dilates and extends them. But this miſerable creature is very far from meeting with ſuch good fortune, as the Ephemerus and Libella, which are in an inſtant brought forth abſolutely perfect. On the other hand, his appendage of misfortunes and trouble, like the tail of the Frog, yet adheres for a long time to him, for he is full of miſery, and is born in tears; and it is very long before he comes to maturity of underſtanding, and full growth of body. It is now time to come to the ſingular hiſtory of the Frog; which is highly worthy of conſideration.

A particular treatiſe on the generation of Frogs.

HAVING hitherto premiſed only general obſervations, and ſuch as tended to explain the figures in Tab. XLVI. I ſhall here treat particularly of the generation of Frogs, and deſcribe the genital parts of the male and female, and ſhall add ſome other obſervations, I hope, of ſome uſe. I would, on firſt ſetting out, inform the reader, that there is a much greater number of miracles, and natural ſecrets in the Frog, than any one hath ever before thought of or diſcovered; as I ſhall evidently demonſtrate, when I ſhall have opportunities to deſcribe particularly the whole hiſtory of that animal; and I am now here to explain a great part of it.

The genital organs of the male are the teſticles, the vaſa deferentia and ſeminal veſicles. The teſticles, Tab. XLVII. Fig. 1. *a a* are placed in the loins, and being there ſituated over the kidneys themſelves, *b b b b*, are furniſhed with arteries, veins, and ſpermatic veſſels. Their figure is not conſtantly the ſame, but is ſometimes obſerved to be more oblong, ſometimes more round, and ſometimes lunated. Some yellow appendages always adhere *c* to the upper part of the teſticles; and theſe appendages are ſometimes ſingle, *d*, ſometimes double, *e*, and at other times triple or quadruple. Theſe little parts likewiſe have their blood veſſels, and conſiſt of ſeveral bags joined together, and containing an oily or fatty matter; and encloſed in ſo many oblong common membranes, produced like appendages. I have likewiſe ſometimes obſerved, that this oily matter was joined to the coat inveſting the teſticles, and diffuſed through half their ſurface. A kind of ſimilar, but white fatty matter, is obſerved in Rats, and ſeveral other animals.

Theſe appendages may be examined with great eaſe in Frogs, that are not bigger than the firſt joint of one's thumb; for, by the help of a microſcope, we then diſtinctly perceive, that they conſiſt of a congeries of minute ſpherical and membranaceous particles, full of a yellow, oily, or fatty ſubſtance; but theſe particles are too ſmall to come under the cognizance of the naked eye, to which they only appear as a bright heap of tranſparent gold duſt.

The teſticles are generally yellow, with many blood veſſels elegantly variegated with black, beautifully running through the coats that inveſt them, Tab. XLVII. Fig. 1. *f*. On ſtripping this coat from off the teſticles, they appear to conſiſt entirely, as it were, of ſmall globules, *g g*, but by making this ſeparation ſlowly, and by careful degrees, we may clearly perceive, that theſe apparent globules are no other than the heads of ſo many ſeminal ducts; ſome of them double, *h*, or divided into branches, that riſe all to the center of the teſticle. In Frogs, therefore, the teſticles is compoſed of ſeminal veſſels; and I have diſcovered the ſame to be the caſe in many other animals, as the cuts I have occaſionally given demonſtrate.

Some pretty conſiderable ſeminal veſſels, *i i*, riſe from the internal ſide of the teſticles; part of them ſingle, and part divided into branches, which convey the ſperm, as it were, by ſo many different ſtreams from the teſticles: this may be eaſily ſeen, on compreſſing or ſqueezing theſe laſt parts ever ſo little; for then the ſeminal veſſels, firſt mentioned, fill with a pale white ſperm. Theſe ſeminal veſſels, or natural diviſions of the paraſtata, run by degrees towards the kidneys, upon which the teſticles lie, and, after paſſing through the coats of the kidneys themſelves, and forming a variety of diviſions, *k k*, they at length diſcharge themſelves into the vaſa deferentia, which are ſeated near the internal edge of the kidneys, *l l l*, and are there united with the ſeminal veſſels already taken notice of.

We muſt here duly obſerve, that the kidneys diſcharge their urine by the vaſa deferentia, thro' which the teſticles, in copulation, eject their ſperm: as in man, the ſperm and urine are diſcharged through the ſame urethra. In man, indeed, there is but a ſingle vas deferens, diſtinct from the ureters; nor has this urine any ſuch paſſage; whereas, in Frogs, the great Architect has thought proper to make the ſame veſſel ſerve both theſe purpoſes; and this, perhaps, he ordained, becauſe it was proper to contract or abridge the number of parts that were to be placed in ſo ſmall a body, and likewiſe becauſe the Frog was to evacuate its ſperm only once a year *.

In the midſt, between the two kidneys, are to be ſeen the arteries, and emulgent or kidney veins, Tab. XLVII. Fig. 1. *m m*; theſe I have but rudely deſigned. They are diſtributed all over the ſurface, and through the ſubſtance of the kidneys, by ſo many ramifications, that great circumſpection is neceſſary, not to confound the ſeminal veſſels, juſt deſcribed, with theſe blood

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* The animalcules in ſemine, are ſeen more eaſily and diſtinctly in the ſperm of the male Frog, than any other way. They who doubt the exiſtence of ſuch animalcules, (for it is at preſent a faſhion to doubt them) have not examined the male ſperm of this creature. The proper ſeaſon in England is the firſt week in April. The veſſels are then full of the fluid, and theſe animals are innumerable in it.

veſſels. Beneath the teſticles, and under the skin of the kidneys, there lie two other ſingular, and ſtrange bodies, *n n*, but I neglected duly examining them.

The vas deferens grows ſmaller by degrees, ſo as to form but one trunk, *o o*, but ſoon again it dilates conſiderably, and in this part we may diſtinctly ſee the ſeminal veſicles lying againſt it, *p p*. Theſe veſicles do not differ in conſtruction from the correſpondent veſſels in man, and other animals, except in regard to their being of a more membranaceous ſubſtance. They open into the vaſa deferentia, and convey to them from a great many little cells, an aqueous ſeminal fluid, which is perhaps the vehicle of the true ſperm. In fine, both theſe veſicles, and the vaſa deferentia are inſerted into the ſurface of the rectum, *q q*, directly under the bottom of the urinary bladder, where I have repreſented both their mouths, by two openings *r* that appear through the ſtraight gut. Upon this laſt inteſtine lies a double urinary bladder, *s s*, into which the urine is conveyed by thoſe ureters, which at the ſame time perform the office of the vaſa deferentia. When firſt I diſcovered theſe vaſa deferentia, I immediately ſearched for the ureters, with a great deal of attention, as I could hardly think, that a veſſel of ſuch importance could ſerve two ſuch different purpoſes. But I afterwards found, that the ureters of the female Frog, were conſtructed in the ſame manner as theſe veſicles in the male; and by this diſcovery, I became thoroughly acquainted with all theſe parts. I have accordingly exhibit them, as they appeared in the ſmaller Frogs, as may be ſeen by inſpecting the ſecond figure.

It is now time to ſay ſomething of the genital parts of the female: theſe are an ovary, uterine tubes, or horns of the uterus, and the uterus itſelf. The ovary lies upon the uterus, with which it is always united; and near the ſame place are the fatty appendages, which I deſcribed in the male Frog, when I treated of the genital parts. The ovary, which is always double, equally occupies the right and left region, and is conſtantly found ſubdivided into lobules. I have ſeen them, to the number of five, on a ſide in ſome Frogs. Nature, however, does not always obſerve the ſame order in this particular, except that the ovary never appears, but divided into more or leſs of theſe parts. The blood veſſels are principally diſtributed through theſe diviſions of the ovary, Tab. XLVII. Fig. III. *a*, and afterwards they diffuſe themſelves all over it. Each lobule is hollow, and wrapped up in its own particular coat; ſo that, by fixing in a little tube, *f*, it may be eaſily diſtended with air, and ſeparated from the neighbouring lobules, *b*. This muſt be done very cautiouſly, becauſe this coat is ſo tender, that any thing of a rough blaſt would burſt it. We may then plainly perceive, that all theſe lobules are confined, each to its own limits, and have not the leaſt communication one with another.

As the coats inveſting the lobules of the ovary are ſo very delicate, the eggs may be ſeen thro' them diſtinctly, *c c*: a perſon that was not very cautious, by directing his eyes and hands to this part, might eaſily fancy to himſelf, that the eggs lay on the outſide of the ovary. Theſe eggs are black, and perfectly round, and generally they have a white or yellow ſpot in the centre. They lie cloſe to the internal ſurface of the coats or membranes that conſtitute the lobules of the ovary, and are fixed there by the blood veſſels, as it were, by ſo many ſhort little ſtalks. This circumſtance is very viſible, in cutting off one or two of the lobules of the ovary, *d*, for then the encloſed eggs ſhew themſelves moſt diſtinctly.

But this experiment cannot be conveniently made, unleſs about the beginning of March, or a little afterwards, as it is chiefly at that ſeaſon, that the ovaries abound with perfect eggs: this is moreover the propereſt time for examining the genital organs. On examining carefully the ovary at this period, we may likewiſe find in it a ſpecies of eggs different from thoſe I have now deſcribed. Theſe are ſmaller, white at firſt, and when pretty well grown, yellowiſh. Theſe laſt eggs, however, are only the rudiments, not yet perfected; and therefore, they remain in the ovary, after it has diſburthened itſelf of all the perfect eggs. But before I treat of this operation, I think proper to deſcribe the uterine tubes or horns.

In Frogs, theſe tubes ariſe very high in the breaſt, from whence they ſtretch in the middle, from one end of the abdomen to the other, and terminate in the uterus, with which they lie concealed in the lower part of the belly, but ſo as to be able to move higher, according as the uterus dilates or contracts itſelf. Every Frog has two ſuch tubes, which are placed, one at one ſide of its body, and the other at the other ſide.

Properly ſpeaking, the ſuperior part of the tube lies near the heart, and is connected on each ſide by the ligament, by which the liver alſo is ſuſpended. In the ſame place, where part of the peritoneum paſſing freely over the heart and pericardium, forms with the liver a diſtinct cavity, in which the heart, wrapped up in its pericardium, lies under the breaſt bone, as in the hollow of the mediaſtinum or diaphragm. To ſee all theſe particulars diſtinctly, it is neceſſary to lay open the Frog's belly a little higher than the extremity of the breaſt-bone, where this bone degenerates into a cartilage; then cut off the membranaceous parts; and laſtly, turn over the breaſt-bone upon the head, and ſecure it in that poſture with a pin, Tab. XLVII. Fig. IV. *a*. Thus we diſcover a conſiderable cavity above and about the point of the heart, *b*, in which the heart lies hid with its pericardium, under the breaſt-bone, as within the diaphragm. At the ſame time, we may ſee on each ſide of the heart, the extreme ends or natural openings of the tubes, *c c*, which moſt firmly and immoveably grow there to the peritoneum, and to the ligament, by which the liver is ſuſpended, ſo that they cannot reach to the ovary, which lies at too great a diſtance from them. Beſides, theſe tubes are very ſlender and delicate. They bend a little, eſpecially where they lie upon the lungs; for they ſtretch over the lungs and the liver, where they ariſe from very ſlender membranaceous beginnings. For this reaſon, they always are ready to collapſe, and are only diſcernible by thoſe who have accuſtomed their eyes to ſuch inquiries by frequent diſſections. Such perſons can readily demonſtrate, or produce them, even without blowing them up.

The remainders of the tubes are moſt elegantly curled, and folded up, as it were, in a great many wonderful plaits, *d d*. And indeed, the ſhortneſs of the animal's body could not admit of any other conſtruction, theſe tubes being ſo very long, that, on meaſuring a ſingle one, ſeated on one ſide of the body, I found it to be upwards of two feet. All theſe beautiful foldings and windings of theſe tubes, are connected by means of a ſlight membrane, through which there run a great number of blood veſſels, *e*, in a very orderly manner.

The extremities of theſe tubes open by wide mouths, *f f*, into the two ſides of the uterus. Theſe mouths appear circular when diſſected, after they they have been inflated and dried; but they are oval when the parts are any ways moiſt, as they then collapſe. The uterus itſelf is double, *g g*: it is of a membranaceous ſubſtance, and is elegantly overſpread with blood veſſels. When full of eggs, it wants very little of being ſpherical in ſhape; but when inflated, it is rather oblong, and ſhaped like a pear: the introduced air gives it a ſomewhat different figure. Finally, the uterus terminates at each ſide of the body, in the rectum, about half an inch from the place where the tubes are inſerted into the uterus. In all Frogs, the ſtraight gut *h* is placed between the right and left portions of the uterus, and ſhews on its forepart the bladder, which is likewiſe double in this place, *i*. I have here mentioned nothing, that I have not diſtinguiſhed with my own ſenſes in a Frog, which had diſcharged its eggs, about half an hour before I diſſected it.

The ſame figure likewiſe repreſents the contracted ovary belonging to the left ſide, *k*, ſeated at a great diſtance from the mouth of the tube, with one imperfect egg, which had not as yet diſengaged itſelf, but remained entangled with the ovary. One of the kidneys likewiſe may be here in part ſeen, *l*, together with the pinguiferous appendages of the ovary, *m*. I alſo exhibit two eggs which I found looſe in the abdomen, *n*, on account of their ſtraying from the mouth of the tube, in the act of copulation. The tube itſelf alſo ſtill contained another egg, *o*, fallen into it, after all the others had been conveyed into the uterus. This was very plain from this egg's not as yet having any white. The ſtomach, *p*, and alſo the ſmall guts appear in their natural ſituation; and a portion of the liver, *q*, and ſome of the fineſt blood veſſels, are diſtributed over the ſurface of the ſtomach. On the ſide of the liver, I repreſent the gall bladder, *r*, and the lungs with their veſſels, *s s*. I made an inciſion into one of the parts, to let the air in it eſcape, that I might the more clearly exhibit the courſe and opening of the tube; the other, on the contrary, being the right, I exhibit as it appeared diſtended with air. The auricle of the heart is repreſented, *t t*, divided by a membrane not unlike a valve; it is tranſparent. I next ſhew, in the ſame place, the ſeparated parts of the abdomen and breaſt, *u u u*, interſperſed with ſome muſcles, having endeavoured as much as poſſible to ſhew all theſe parts in one and the ſame figure, and of their natural bigneſs.

Here I cannot omit the opportunity of illuſtrating the account of Oligerus Jacobæus, who owns he could not diſcover the opening of the tube, and of ſhewing him at the ſame time how much he was miſtaken in thinking, that the tube was inſerted into the ſtraight gut, which he has repreſented in an imperfect drawing. I ſhall tranſcribe his words, eſpecially as he has thought proper to charge me with the error which himſelf committed, a proceeding to which he was perhaps prompted, by the flatteries beſtowed on him by the younger Bartholin, who extols, in the moſt diſguſtful manner, this author, and his treatiſe on Frogs. But his panegerick ſerves only to prove, that he underſtands nothing of the moſt curious branches of anatomy; otherwiſe he would be more cautious, not to cenſure in ſo ſupercilious and dictatorial a manner, performances which he has not ſufficient abilities to underſtand. For this reaſon alſo, he appears a great deal more ſolicitous about the external appearance, than about the real nature of the ſubjects he takes in hand. This may evidently appear by his treatiſe on the diaphragm, in which he has been at more pains to expreſs neatly, his own face and hair, than to make the figures of the things he treats of plain and intelligible, as if the learned were in love with his countenance.

The words of the illuſtrious Jacobæus, in his obſervations upon Frogs, are as follow: "This tube, in the upper part, hides itſelf in the region of the heart, liver, and lungs; but where it afterwards ſtretches its courſe, I cannot tell, as I could not get the air I ejected for that purpoſe, to aſcend any higher than this part. Below, where it runs under the ovary, it dilates into a pretty wide oval mouth, and branches into fibres that unite with the kidneys and ovary, whilſt the reſt of it is inſerted into the ſtraight gut, about a thumb's breadth from the oval mouth juſt now mentioned." He afterwards adds, "Swammerdam, though very clear ſighted upon every other occaſion, does not ſeem to have taken notice of this oval mouth, when in his treatiſe on the conſtruction of the womb in women, he ſays, that in Frogs, the motion of the egg from the ovary, to the tubes and arteries, is more obſcure, as he tells us, the orifice of the horns of the uterus, or of the tubes, are about two fingers breadth diſtant from the ovary, and that not only their orifice is very narrow, but the part alſo is unmoveable; and further, he denies that it lies cloſe to the ovary, as in the females of the human and feathered ſpecies."

We may reaſonably imagine, this learned author did not ſo much as think of any part of the uterus; for he does not, in his whole treatiſe, make the leaſt mention of that part, and affirms, that the tube is inſerted into the ſtraight gut; whereas, on the contrary, it is the uterus itſelf that is inſerted into that inteſtine, and by no means the tube. Beſides, the ovary of Frogs is never found to have naturally that figure, which Jacobæus very raſhly gives it, though it is to be obſerved, that the uterus, when loaded with eggs, is found on diſſection to have, in ſome degree, ſuch an appearance. Therefore, the oval oſtium, or mouth, which this author mentions, is, in my account, really the opening of the tube into the uterus, which, properly ſpeaking, ſhews itſelf where the tube ends, and the uterus commences. See Tab. XLVII. Fig. iv. letters *ff*, where I have at large deſcribed all theſe parts.

Such being exactly the caſe, and it being at the ſame time certain, that the inferior extremity of the tube has no communication with the ovary; and that no eggs can enter there from the lobules of the ovary, which are perfectly cloſed; and as likewiſe M. Jacobæus could not diſcover the upper orifices of the tubes, I would be glad to know in what manner this author can explain the paſſage of the eggs from the ovary, into and through the tube. I really cannot conceive how he can acquit himſelf of this taſk; ſo that he has in good earneſt made the motion of the egg, from the ovary more obſcure, than he is pleaſed to fancy I had done. But I, by no means intend to enter the liſts with this gentleman, or imprudently treat him with rough language; for it is not in ſearch of glory to ourſelves, but the great Creator, that we ought to ſurvey and examine his works. For this reaſon, I rather look upon myſelf as under an obligation to this illuſtrious naturaliſt, for having condeſcended to criticiſe, and bring to the teſt my experiments concerning Frogs; and, in the ſame ſpirit, I muſt tell him, that he can never miſs finding the opening of the tubes near the heart, provided he looks for it a little after the Frogs have depoſited their eggs. At this time, even the whole uterus may be diſtended with air through the tube; and, on the other hand, from below, upwards, the tube thro' the uterus. What is ſtill more, theſe openings of the tubes may be then diſcovered without any diſſections, by only blowing ſlightly through a pipe in the adjoining part of the heart. But none of theſe experiments will ſucceed, whilſt the eggs are only in their paſſage through the tube, at which time, perhaps Jacobæus ſurveyed theſe parts. Thus the natural opening of the tube becomes very diſcernible to thoſe who take a right method to diſcover it. But is it not ſurpriſing, that the deſcription given by me, and which Jacobæus muſt have ſeen, as he quotes it, did not open his eyes; for, though ſhort, it is very plain and intelligible. Mankind is liable to error; but, to perſiſt in it, after friendly admonition, ſhews a perverſe arrogance, that will not ſubmit to acknowledge its miſtakes.

It is now time to ſpeak of the egg's paſſage through the tube, from the ovary into the uterus, which is indeed not only difficult to expreſs in words, but even to conceive, ſo that in the whole ſcience of anatomy, equally abſtruſe and myſterious, I muſt own, that this is very obſcure in many other animals, but in Frogs, it is altogether incomprehenſible; for the ovary, as I remarked above, and am ready to demonſtrate in the Frog itſelf, does not in any way communicate either with the tube or with the uterus. The opening of the tube cannot by any means move itſelf towards the ovary. Beſides, there are no other mouths at which the eggs can be received, than the narrow membranaceous orifices of the tubes, which above grow to the membranes of the heart; ſo that there does not appear in this place the leaſt trace of any oval mouth, by which it is ſaid, that the tube opens itſelf about the inferior region of the ovary; for it is very eaſy to ſeparate the tube and ovary from one another: and the ovary afterwards extracted from the body, may by itſelf be diſtended with air, and dried, not having the leaſt aperture to let the air eſcape, or the leaſt mark of ever having had one.

I have ſometimes diſtinctly obſerved in breeding Frogs, that whereas the ovary of one that I diſſected, about the beginning of April, ſtill contained all its eggs; that of another, opened a few days afterwards, had loſt the greateſt part of them, Tab. XLVII. Fig. v. *a*. I could likewiſe, at the ſame time, eaſily diſcover a great many of the eggs that had eſcaped out of the uterus, and were broken, lying here and there in the abdomen *bbb*, between the lungs, and under the ſinuſes of the ſtomach and inteſtines, among the membranaceous parts of the viſcera, and elſewhere. Some alſo appeared near the opening of the tubes *c*. Others were ſtill adhering to its inſide *ddd*, part in its higher, and part in its lower region. I even diſcovered an egg lying at the very mouth of the tube *e*, and in what manner the eggs were leiſurely forced thro' the extremity of the tube into the uterus *ff*. I obſerved alſo, that the greateſt part of the eggs ſtill adhered to the uterus; which I here repreſent two ways. Firſt, I exhibit the uterus as it naturally appears *g*, with the contained eggs viſible thro' it, but very faintly; and on the other ſide I repreſent it as it looks, after having been macerated in water, or on its beginning to dry, after being expoſed to the open air for ſome time; in both which caſes it very diſtinctly ſhews the eggs ſhut up in its cavity *h*. I repreſent beſides, lower down, the extremity of the double uterus *i*, which is inſerted into the ſtraight gut, about half an inch from the opening of the tubes into the uterus. Near the heart appears the beginning of the great artery, with two ſmaller arteries ſpringing from it *k*. On each ſide, near the heart, are openings of the tubes *ll*; and I have repreſented the lungs as bearing upon theſe openings *mm*, in order to render their ſituation next above the lungs more diſtinctly perceivable. It is very remarkable, that living Worms are almoſt always found in the lungs of Frogs; I have often met with ſix in one Frog.*

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* Naturaliſts have been perplexed extremely to account for the Worms found in the inteſtines; but theſe are much more ſtrangely ſituated. They cannot have been ſwallowed in food by the Frog, for this would not be their place. The opinion of Valliſnieri is, that the Worms found in our inteſtines, were created with the human frame; and that the bowels are their natural and proper place of living: it is much more ſtrongly probable here.

Theſe Worms are, on their fore part, pretty like Lumbrici terreſtres, or common Earth-worms, but on their hinder part they are ſomewhat thicker, and they generally lie in plaits and folds within the lungs. In ſize they differ but little from the Worm that gnaws or corrodes the ſhell of the common Wilk. Their colour is a yellowiſh white, except that they are black towards the tail, which variety in colour proceeds from that of the food they have taken into their bodies. They have their mouths conſtantly fixed to the internal membranes of the lungs, from which they ſuck the blood. On ſeparating them cautiouſly from theſe membranes, we may diſcover in the membranes a little opening made by theſe inſects, and even a ſmall quantity of blood diſcharged from that aperture: the mouth alſo of the piratical Worm appears bloody, if immediately inſpected. Theſe Worms appear to have another aperture in their breaſt, which however I did not ſufficiently examine. I omitted alſo taking a ſurvey of their inſide, except that I obſerved ſome great and ſmall guts, and ſome diſtinct particles; but the inſect's ſkin being tranſparent, theſe particulars could be ſeen without diſſection.

Other kinds of Worms are often found alſo in the lungs of Frogs. Theſe are like briſtles, with ſharp heads and tails, and they coil themſelves up. In colour they differ little from the firſt kind, only that on the inſide of their bodies they ſhew thro' their tranſparent ſkins, ſome of their inteſtines in the form of a little thread or line of a duſky brown. On opening both theſe ſpecies of Worms, immediately taken from the Frog, I found in them a great number of ſmall particles wrapped up in an oblong membrane. On obſerving that theſe particles were not only all of the ſame ſize, but were likewiſe regularly placed as in an oviduct, my curioſity led me to examine them with a microſcope, by which I at length convinced myſelf that this prodigious number of particles was no other than ſo many roundiſh, or oblong eggs, in which alſo there was a very diſcernible motion. This induced me to open ſome of them. But how great was my ſurpriſe on finding, that every egg contained a minute but perfect Worm lying folded up in it, like a young ſerpent in its egg! Even theſe little Worms, when extracted from their eggs, moved themſelves exactly in the ſame manner with the parent-inſect. This was an undeniable proof, that this Worm was both oviparous and viviparous; thus propagating its ſpecies in the moſt ſurpriſing manner. But I return to my proper taſk; for this little animal, tho' no longer than a young Frog ten days old, contained too many miracles to be publiſhed in a few pages.

To return therefore to the Frog itſelf, what I have ſaid ſufficiently ſhews, how the eggs are diſperſed, when they break the ovary, and from thence roll into the cavity of the abdomen. But I would fain know, by what art, regular motion, or contrivance an egg lying thus looſely in the body, can be conveyed into a narrow tube, whoſe opening is placed very high up near the heart? Certainly, the beſt thing we can do on this occaſion, is to own ſuch a conveyance utterly inconceivable by human underſtanding, and humbly to acknowledge the narrow limits of our faculties. It cannot be denied, that at this time, the ovary is diſtended very much towards the upper parts of the belly, by the great ſize and number of the eggs it contains; nevertheleſs, the eggs which poſſeſs the lower part of the ovary, never lie nearer than within two fingers breadth from the opening of the tube; and in the largeſt Frogs, they are at a greater diſtance. Let us ſuppoſe them ever ſo near the tube, who will tell us how they can get into the opening of it, which ſome of the beſt anatomiſts could not diſcover. The eggs have no motion of their own; nor are there any muſcles in the way to move them. I therefore conclude, that this motion of the eggs of Frogs lies hid in a myſterious darkneſs, too thick for human underſtanding to penetrate.

But however incomprehenſible this motion may be, we may derive from it great light into the motion of the eggs in women, in whom this tube is moveable; ſo that it can apply its mouth to the ovary, in order to receive the egg falling from this laſt part, a thing which that induſtrious anatomiſt Bidloo ſaw, and procured a drawing of. I have myſelf obſerved more than fifty times in Frogs, that the eggs which had broken looſe from the lobules of the ovary, had inſinuated themſelves into the tube, and thro' the tube into the uterus; nor do I ſee any manner of difficulty in conceiving how in any animals the egg once got into the tube, ſhould from thence paſs to the uterus, the difficulty entirely lies in the paſſage of the egg from the ovary to the tube. In the Frog there is all the reaſon in the world to call this motion a miracle; indeed, there is nothing to hinder us from giving it the ſame appellation in all other animals. The cauſes of wonder are the ſame in all; and in general, the motions of eggs ſerve moſt manifeſtly to prove, that the human underſtanding is confined within very narrow bounds.

I have ſometimes counted upwards of eleven hundred eggs in one Frog, all which are to paſs thro' the narrow, immoveable mouths of theſe two tubes; nor can ſuch paſſage be looked upon as an eaſy matter, as theſe tubes ſcarce deſerve to be conſidered as ſimple channels, but rather as the horns of the uterus, which other animals exhibit. The white of the egg is formed in them, to ſurround the Frog's egg, or fœtus, and afford the young animal nouriſhment for ſome days in the ſame manner as the colliquamentum, or white, does the Chicken. On this account alſo, it is impoſſible to diſtend theſe tubes with air at this time; it is even a difficult matter to alter, even by ſqueezing with the fingers, the ſituation of the eggs at that time faſtened within the tubes, the matter ſupplied by them, for the nouriſhment of the Frog's fœtus, which it moſt regularly ſurrounds, being very clammy and glutinous. For this reaſon the eggs do not paſs faſt, or eaſy thro' the tubes, but very leiſurely, and by ſlow degrees, and chiefly by the action of the muſcular fibres adminiſtring to the tubes, which little by little puſh the egg and its nouriſhment into the uterus.

I find this white of eggs to be a very nouriſhing ſubſtance; for which reaſon, when I had young Frogs to rear, I uſed, as often as I wanted, other food that was proper for them, to take a tube from the body of a female Frog, and give it to them cut into pieces, which they immediately faſtened upon, ſucking eagerly the juices that flowed from thence. This matter even diſſolves, and diffuſes itſelf in water, like the white of the Frog's egg, being of a ſimilar compoſition and ſubſtance: hence the tube itſelf, on being juſt thrown into water, becomes by degrees eight times as thick as before: but this experiment muſt be made within a few weeks of the eggs paſſing thro' the tubes, as afterwards they contain no more of the white or albumen.

This tube, no doubt, is furniſhed with its glands; tho' as yet I have not had the ſatisfaction of ſeeing them diſtinctly. I obſerved, however, that the tube on its inſide is thoroughly lined with a regular reticulated glandulous coat; from whoſe pores the albumen, or white is ſecreted. Behold what, and how many wonders appear in the Frog only! But we ought not to content ourſelves with a ſingle experiment; we ought to try every thing that appears, and in every manner in which it can be tried, to acquire a perfect knowledge of any thing we deſire to be thoroughly acquainted with.

It is no eaſy matter to determine whether the uterus contributes alſo to the generation of the white of the egg, and the full perfection of the egg itſelf, or only ſerves to collect all the eggs, and eject them at one and the ſame time. To me it appears probable, that the uterus ſerves merely as a receptacle for the eggs. It differs greatly from the tubes, as it is membranaceous, and in part fibrous, or compoſed of, or furniſhed with many fibres; but it is no ways glandular, for which reaſon it is always found in a contracted ſtate, and never exhibits itſelf diſtinctly, but when naturally diſtended with eggs, blown up with air, or injected with ſome kind of liquid. It is even impoſſible to diſtend it by macerating it in water; ſo that upon the whole, no two things can be more different than the tube and the uterus.

The eggs, as I ſaid before, at the time that the Frog is to diſcharge them, break looſe from the lobules of the ovary, to the inſides of which they adhered, and are forced by I know not what motion thro' the cavity of the abdomen into the open mouths of the tubes; but I cannot exactly determine how much time may be requiſite for this paſſage, as the Frog is very far from being tranſparent like ſome other animals. It may not, perhaps, be impoſſible to obſerve this proceſs in ſome other ſpecies: nevertheleſs, the knowledge of this truth could then be only analogically obtained.

About the ſame time we find that the teſticles and ſpermatic veſſels in the male Frog fill with ſperm. Theſe animals become then ſo eagerly intent on the buſineſs of propagation, that they take no care in a manner of their own ſafety; ſo that they may be eaſily caught with the hand. I believe that they eat nothing, or very little, during this fit of luſt, which laſts more or leſs time, according to the heat of the weather.

To carry on the intercourſe of the ſexes, which this great work requires, the male Frog leaps upon the female, and when ſeated on her back, he faſtens himſelf to her very firmly. For this reaſon, the Dutch country boors, with great propriety, tho' in their vulgar way, call this manner of copulation, the riding ſeaſon of the Frogs, as the male is carried about, riding, as it were, by the female.

It is neceſſary, thoſe who intend to diſſect this inſect, ſhould know how to diſtinguiſh the male from the female. I have obſerved two marks by which this diſtinction may be made. In the firſt place, the male has two air bladders, which he expands in croaking; and the mouths of theſe bladders are ſeated on the ſides of his jaws. Theſe bladders conſiſt of two membranes, which may be eaſily parted, and ſeparately diſtended with air, and ſo preſerved. One of theſe membranes is a continuation of the external ſkin; the other a continuation of the membrane of the palate; and this laſt is furniſhed with blood veſſels and muſcular fibres, which ſerve to contract and dilate theſe bladders. Properly ſpeaking, the orifices of theſe bladders lie in the upper region of the mouth, where the gums are ſeated in men; and near them, within the mouth likewiſe, are to be ſeen the orifices of the organs of hearing, or of the animals ears. The tympanum, or drum of the ear, lies withoutſide, immediately under the ſkin. The ſame conſtruction obtains alſo in the Chameleon.

The other mark of the male Frog is furniſhed by the animal's thumb, which is very thick in the males, Tab. XLVII. Fig. VI. *a.* perfectly black in ſome kinds, and covered with a great number of papillæ, *b*, which are likewiſe of an extreme blackneſs, and conſtructed in the ſame manner with the papillæ on the tongues of oxen. Theſe papillæ become rough in drying, and, like the rough ſkin called ſhagreen, feel very ruggid; their uſe I ſhall preſently deſcribe.

The males, at the time of copulation, leap on the females, and they continue ſometimes on their backs, for forty days ſucceſſively, according as the ſeaſon of the year is more or leſs cold, and the eggs take up more or leſs time in their paſſage to the organ that is to ſhed them. Sometimes theſe animals continue together in this manner even for a much longer time; as when the female is weak or ſickly, and the eggs on that account deſcend more ſlowly through the tubes to the uterus, or when they meet with delays in the abdomen or uterus, as I obſerved in ſome Frogs, whoſe intercourſe laſted a very long time.

The very moment the female has depoſited her eggs, the male forſakes her, having performed the taſk, for which this luſt was ſo wiſely deſigned.

This wonderful copulation is perfomed in the the following manner. As ſoon as the male has leapt upon the female, he throws his forelegs round her breaſt, Tab. XLVIII. Fig. I and II. *a a*, and cloſes them ſo firmly, that I found it impoſſible to looſen them with my naked hands without wounding them; ſo that I found myſelf under a neceſſity of introducing an iron ſpatula, between the female's breaſt and the male's legs, the better to ſeparate them. The male moſt beautifully joins his toes between one another, in the ſame manner as people do their fingers at prayers. His head reſts on that of the female, *b b*, but in the hinder part, his body hangs a great deal lower than her's, as he lies ſo much more backwards than ſhe does: this poſture has its uſe, which I ſhall hereafter relate. The thumbs of the male's forefeet preſs with their thickeſt ſides againſt the breaſt of the female, and the extreme joints of the thumbs are bent a little.

Let the female ſhake herſelf ever ſo much at this time, the male never lets go his hold, even tho' ſhe ſhould get out of the water, ſo that one may carry them any where in this poſture; which is likewiſe the caſe of garden Snails, when engaged in the ſame buſineſs. Such is the male's eagerneſs to act his part, that he is not to be parted from his mate, even by pulling him forcibly from her by his hind legs. Thus theſe little animals ſwim, creep, and live together for many days ſucceſſively, till the female has ſhed her eggs, which, at length, ſhe does in a manner inſtantaneouſly. I obſerved, that when they breathed, during this intercourſe, the external ſkin, which immediately covers the drum of the ear that lies under it, near the eyes, Tab. XLVIII. Fig. I. *cc*, continually heaved up, and then fell again againſt that organ of hearing; and this alternate elevation and depreſſion affords a pretty ſpectacle, when they both breathe, and open and ſhut their noſtrils by turns.

It may be aſked, at what time the male leaps upon the female? Whether it be before the eggs have paſſed through the tubes, or after this, when they are already heaped up in the uterus? But this circumſtance I omitted to examine. However, I cannot help delivering it as my opinion, that the male aſcends the female when the eggs have been taken up by the tubes, and ſome of them have begun to adhere to the uterus. My reaſon for thinking ſo is, that otherwiſe the male might defeat all his endeavours, by compreſſing and cloſing with his arms the mouths of the tubes. Perhaps, alſo, it is for this reaſon, that ſometimes ſome of the eggs remain in the abdomen, after the others have been ejected. But a certainty, in theſe caſes, might be eaſily obtained by diſſection.

When, therefore, all the eggs of the female are got together in her uterus, the tubes are quite empty; and when every egg has received its coat of white in theſe tubes, or in the horns of the uterus, ſhe throws them all out together by a ſingle effort; and, while this is doing, it may be obſerved, that the male acts the part of a midwife, and promotes the expulſion of the eggs by working with his thumbs, and compreſſing the female's body harder with his fore legs. Thus, at laſt, the eggs are diſcharged at the female's fundament in a long ſtream, *d*; and the male, who has no penis, immediately fecundifies, fertilizes, or impregnates them, by an effuſion of his ſperm, which he likewiſe diſcharges at the anus, *e*, *. But as the eggs, rendered very clammy and glutinous by the white that inveſted them, have grown together, had been compreſſed in the uterus, they immediately, on being caſt into the water, expand themſelves into their former round form, *f*. Hence appears the neceſſity of the hinder part of the male's body hanging more backwards than the female's. As ſoon as theſe eggs have eſcaped from the female's body, between her's and the male's hinder legs, and have been impregnated by the male's ſperm, the two Frogs abandon each other. The male ſwims off, and works his fore feet as before, though they had continued ſo many days ſucceſſively, without the leaſt motion, in the moſt violent ſtate of contraction.

The eggs thus dropt, immediately ſink to the bottom of the water, unleſs hindered by weeds that grow in ditches, or the like; and in a few days they return to the ſurface again, if not ſtopped in the ſame manner. I opened a female about two hours after ſhe had diſcharged her eggs in a glaſs veſſel, where I had kept her for that purpoſe, and found the ovary perfectly contracted, as I have repreſented it in the fourth figure of the forty-ſeventh plate, under the letter *k*. Beſides, there ſtill remained ſome eggs in the abdomen, one in the ovary, and one likewiſe in the tube.

Upon my proceeding, after this, to examine the ovary, which was emptied of its eggs, I diſcovered, in diſſecting the body, three different ſpecies of muſcles; namely, ſtraight ones, interſected by four lines, and oblique deſcending and aſcending muſcles, lying under the former. When I had laid open the abdomen, I obſerved a very remarkable ſingularity in the ovary. In the firſt place, I could diſcern in it eggs of four different ſizes and colours. Some of theſe were very ſmall and white, Tab. XLVIII. Fig. III. *a a*; others a little bigger, and yellow, *b*; a third kind was a good deal bigger ſtill, *c*, and of a duſky colour. There were likewiſe in this part a great many black little ſpots, *d*, which, at firſt ſight, I took for ſo many eggs; but the microſcope proved they were irregular particles, or eggs beginning to decay.

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* It had been ſuppoſed that this method of impregnation was peculiar to Fiſhes; but this is one inſtance of the contrary. Something nearly analogous is the caſe with the Water-Newt, and probably future experiments will ſhew it in other water animals.

On opening afterwards ſome of the lobes, all the foregoing particulars appeared ſtill more diſtinctly; the cauſe of the blood-veſſels amongſt the eggs being very diſcernible, *e*, as likewiſe the manner in which the eggs were placed upon the ſmaller ramifications of theſe veſſels. When I had attentively ſurveyed and conſidered all theſe things, I judged them to be the rudiments of the eggs, that were to be ſhed the enſuing ſeaſon; tho' afterwards the irregularity of their figure, and their difference in ſize, made me alter my opinion.

Finally, I found at the bottom of the membranes, which conſtituted the globules, and amongſt the eggs I have juſt now mentioned, ſome empty and very delicate membranes, Fig. IV. *aaa*, which had ſerved to inveſt the eggs that had been already diſcharged from the ovary; in the ſame manner as it appears in the cluſter of eggs in Hens, which ſtill retain, after the yolks have left them, the little membranes and cells which ſurrounded thoſe yolks; though, in courſe of time, theſe traces contract themſelves by degrees, and entirely diſappear. Theſe particles were moſt beautifully interwoven with blood-veſſels, to which they were fixed as to ſo many ſtalks, *bb*; as I have endeavoured to ſhew both one and the other, and at the ſame time one of the largeſt blood-veſſels, *cc*; but all of them conſiderably magnified.

This obſervation gave me reaſon to think, that the eggs I have been laſt ſpeaking of, might be, as it were, like fruits, which had not as yet attained their due point of perfection, and might wither and drop off, before they did ſo; and I found this to be the caſe, even with perfect eggs, that had remained in the ovary and abdomen, as I have in part repreſented under the letter *f*, of the third figure. Theſe little membranes, which I have been deſcribing, were torn, as it were, and ſo collapſed as to form a ſmooth plain ſurface; for which reaſon I exhibit only a few of them. But it is time to ſee now what becomes of the eggs, when they are diſcharged by the creatures now under conſideration.

Of the manner in which the young Frogs or Tadpoles grow in their parent's eggs, and are in due time hatched or delivered from them.

THE very next day after the eggs had been diſcharged, being the 18th of April, they were of the bigneſs repreſented at (1); and the albumen, or white, which ſurrounded them, was very inconſiderable: but I could ſee they grew from one minute to another, ſo that the day next following they were of the ſize at figure (2). The white, in proportion as the water gradually penetrated it, grew on every ſide more and more clear and tranſparent; but the inſide, which immediately contained the embryo Frog, rather looked like an agate. As to the fœtus itſelf, I could diſcern no alteration in it. But not content with external appearances, I reſolved to examine thoroughly theſe eggs; but the ſurpriſing toughneſs of the white threw ſuch obſtacles in my way, that all my endeavours ended in nothing: and though I, at laſt, ſtripped the embryo of the coats and other ſubſtances in which it was wrapped up, it was ſo cruſhed, and otherwiſe diſturbed by my handling it in the operation, that I could not by any means ſatisfy my curioſity.

This diſappointment obliged me to take another method. I put a large number of theſe eggs into different liquors, in hopes ſome of theſe fluids might prove a ſufficient menſtruum to diſſolve the white. At the ſame time I boiled, with the ſame view, ſome of theſe eggs in water; by which means I indeed ſucceeded, but not as perfectly as I deſired. However, I could ſee that the ſkin of the encloſed Frog was regularly wrinkled, as in boiling it had loſt by evaporation ſome of its humours.

On ſurveying the next day the eggs I had put into the other liquids, I found that the whites had been coagulated by the liquor, whoſe effects I firſt attended to, ſo as to appear of a beautiful roundneſs, like bunches of grapes. In colour they in a manner reſembled an agate, or the boiled egg of a Lapwing. The little encloſed animal was alſo coagulated, ſo as not to fall aſunder on diſſection, though I could then more eaſily diveſt it of the yolk.

In another liquor the eggs had acquired a purple colour; but very little of the white was diſſolved. I therefore paſſed to a third liquor, in which I found the white of the eggs was become more milky, and was a little diſſolved; and it had beſides loſt a great deal of its clamminess and tenacity. The little Frog itſelf was increaſed to twice its ſize, and all its contents had in ſome meaſure contracted a colour: both which circumſtances afforded me a very convenient opportunity of examining thoroughly, and with great care, the firſt rudiments of this little animal.

The whites of the eggs in the fourth liquor had aſſumed a greeniſh hue, and wanted little of being entirely diſſolved; ſo that here alſo I could very conveniently ſurvey every part of the young Frog, eſpecially as this was alſo entirely coagulated in the ſame manner with the yolk of a boiled egg. Theſe were the different effects, on various parts, performed by one and the ſame liquor. On examining, therefore, with a microſcope; the encloſed young creature, I found it to conſiſt entirely of minute grains, which were in a manner uniformly divided, and were yellow and tranſparent, without any other contents or viſcera, that I could diſcover. The little animal was alſo divided throughout, as it were, into two parts, by a very conſiderable furrow or fold, Tab. XLVIII. Fig. v. *a a*. In the upper part there ſtill remained ſome traces of a little yellow ſpot, that appeared there by ſome little openings, cracks, or crevices, *b*. But on opening afterwards the egg, according to the courſe of the furrow juſt now mentioned, I could diſcern that, on one ſide of the fœtus, this furrow reached almoſt to the middle of its body, where this body was alſo ſomewhat convex, Fig. vi. *a*, in one part; and in the other part, to which that furrow equally penetrated, it was hollowed into a cavity, *b*, which received the convexity of the firſt. On the oppoſite ſide of the fœtus the furrow was not, by a great deal, ſo deep, *c c*, ſo that it juſt looked like a ſuperficial cut on the ſkin. The broken ſubſtance of the young Frog's body, compoſed of grains, *d d*, ſhewed itſelf in the place where theſe furrows terminated within.

I afterwards diſcovered in a perfect Frog alſo this parting or diviſion, which I at firſt obſerved by mere chance in the embryos of this animal; and this new diſcovery procured me great facility in accounting for that ſudden expanſion and elongation of the young Frog's body, on the fourth day, when it explicates or unfolds itſelf. Hence I believe, that one part of the unfolded embryo forms the head and thorax of the future perfect animal, and the other part the abdomen and tail, which grows larger and larger by degrees.

In the fifth liquor, where I had put ſome of the eggs, their whites were grown a little rediſh, and were almoſt diſſolved; but the encloſed embryos had ſhrunk up a little: by which means I obtained a ſight of a very limpid humour, that ſurrounded the young Frogs, and was itſelf encloſed in a delicate diſtinct coat or membrane. On examining theſe appearances with a great deal of attention, I diſcovered, that, on one ſide, this membrane looked like the allentoies, Fig. vii. *a*; and I could even diſcern, in the cavity of it, a little white coagulated particle, floating in the encloſed liquor. The furrow, already mentioned, was likewiſe viſible in the midſt of this egg, *b*; and, on the other ſide, the little yellow ſpot, diſcernible in the fœtus, ſhewed itſelf through the tranſparent membrane which inveſted it, *c*. This yellow ſpot differs in nothing from the other parts of the embryo Frog, except that the folds of the body are here larger than elſewhere; and for the ſame reaſon, in proportion as the Frog grows, this yellowneſs gradually wears away, and changes to black.

This ſecond diſcovery gave me room to ſuſpect, that the Frog's egg might likewiſe leave its amnion and its chorion; and I had afterwards the pleaſure of diſcovering theſe membranes, though I cannot take upon me to ſay, that they can be diſtinguiſhed one from another. But I know for certain, that the Frog is wrapped up in a coat or membrane, which is very diſtinctly conſpicuous; and that it floats, moves, and turns itſelf in a moſt limpid fluid contained in this coat, juſt in the ſame manner as the Chicken does in its colliquamentum, or white.

This ſingular obſervation made me exceſſively eager to ſearch, to the bottom, theſe wonderful and ſurpriſing myſteries of Nature. I therefore examined this egg again, touching it a little more roughly. By this means the allentoies dilated itſelf by degrees, Fig. viii. *a*, as I thus forced into that membrane all the liquid contained in the amnion; from which however, on removing the little inſtrument with which I had preſſed it, it returned to its proper ſituation.

At length, by treating this egg ſtill more roughly, I ſucceeded ſo far as to make the allentoies fall off from the Frog; and as, in ſo doing, I wounded the creature, I could diſcern its black fluid particles flowing into the allantois, and at the ſame time diſturbing the liquor of the amnion, which it diſtended, thereby giving it the ſhape of a Pear, Fig. ix. *a*; I therefore continued this operation, till every part of the allentoies was thoroughly expanded by the fluid particles of the wounded fœtus; as may be ſeen in the tenth figure, done after nature, but enlarged. With all this harſh uſage, I had not as yet broken any of the membranes.

I next took a ſurvey of the Frog's inſide; but I diſcovered nothing diſtinct enough to deſerve mention. I could only diſcern the little grains I have already deſcribed, and from which, as from a congeries of coagulated and united globules, this little animal ſeems to derive its origin. The menſtruums had produced in this granulated ſubſtance a beautiful variety of colours, as yellow, white, purple, and many others.

The obſervations already mentioned, had thrown ſo much light upon the ſubject of my preſent inquiries, that the third day after the eggs had been diſcharged, Tab. XLVIII. (3), I could pretty clearly diſcern the young Frog floating in the liquor of the amnion, and ſee that it was now gradually expanding itſelf. The whole egg alſo was grown much larger, by the water and food it had imbibed. The albumen that lay next the Frog was ſomewhat whiter than before; and I even thought that I could perceive in this ſubſtance ſome white veſſels, which, as I ſuſpected, might ſerve to encreaſe the white of the egg, and convey it to the embryo. We may therefore reaſonably conclude this has its umbilical veſſels, though too ſmall to be diſcerned. I unhappily neglected this day to put any eggs into the menſtruums I had prepared to coagulate them, and thereby to obtain an opportunity of looking for theſe umbilical veſſels.

On the fourth day 4 4 4 4, all theſe particulars were ſo viſible, even without the aſſiſtance of a microſcope, as not to leave the leaſt room to doubt of their exiſtence; eſpecially as the colliquamentum, or white, and the coats inveſting the embryo, were likewiſe greatly increaſed in ſize, and the Frog had unfolded and diſplayed itſelf under a variety of forms; as may be ſeen in the figures I have given, to repreſent them of their natural dimenſions.

The ſame was to be ſeen on the fifth day, and formed a moſt ſurpriſing and beautiful appearance. I could now alſo diſcover by what means the chorion and amnion dilate themſelves gradually, in the middle of the white. The ring alſo, formed by the white veſſels of the chorion growing round its circumference, was now extending itſelf; but with all this, no umbilical veſſels yet appeared in the colliquamentum of the amnion, though this liquor was as tranſparent as chryſtal. I could now alſo moſt diſtinctly diſcern the diviſion of the young Frog into head, thorax, belly, and tail, as well as the manner in which it was beautifully adorned about its thorax, and near its head, with ſome black ſpines, diſpoſed like a border, and highly worth our notice, as I ſhall hereafter explain. All theſe things may be ſeen in the figure, number 5, Tab. XLVIII.

I muſt here obſerve, that I could not now any longer diſcover the allentoies; but whether the ſight of it was intercepted by the dilatation of the chorion or amnion, or whether it had only conſiſted originally of the folds of theſe membranes, or in what other manner this difficulty may be explained, I cannot take upon me yet to determine. It was matter of great entertainment to me, this day, to ſee the embryo Frogs rolling and tumbling about, almoſt perpetually, in the ſurrounding amnion.

On the middle of the ſixth day I could perceive, that ſome of the young Frogs had diſengaged themſelves from the chorion and amnion, and deſerted the albumen, or white of the eggs; whilſt others were only preparing to break looſe, and others again had not even attained ſo much ſtrength and perfection as theſe. I obſerved alſo, that ſome of the eggs had increaſed in ſize, without unfolding themſelves; and theſe, I believe, were ſuch as had not been impregnated by the male's ſperm. I afterwards met with two albumina, or whites, which did not now contain, and never had contained, any Frogs, though I could diſcern in them a white ſpot; ſo that perhaps theſe were imperfect eggs, which had dropt from the ovary with the reſt, and had received equally with them their proportion of albumen, in paſſing through the tubes. Thus did I, in this ſubject, diſcover a great many of Nature's miraculous operations.

The tenth day (10) I had the pleaſure of ſeeing the young Frogs, which had deſerted their albumina, in an almoſt perpetual motion, ſwimming alternately to this their primitive habitation, and then from it again, for the ſake of reſt and food. Theſe Frogs were of the form repreſented by the figure, number 10, and they were grown very little larger; but I thought it very remarkable, that the little black appendages, like borders, before mentioned, were greatly increaſed in bulk. Theſe ſpines, it is probable, were intended by Nature to aſſiſt the little animal in ſwimming, as well as in remaining quiet and repoſing itſelf in the white. They greatly added to the beauty and ſingularity of its appearance, according to the judgment I had at firſt ſight formed of them.

On the 15th I diligently ſurveyed, through the microſcope, the external parts of the young Frog, as I have repreſented in two ſeparate figures, of its natural ſize, in Fig. XI. and in Fig. XII, *a*, of the ſize given by the microſcope, when laid upon its back. I could now moſt plainly diſcern its diviſion into head, thorax, belly, and tail. The eyes lay on each ſide of the head, Fig. XII. *a a*, and were beginning to project a little, though they ſtill appeared as if they were ſhut. On the fore part, between the eyes, appeared the animal's wide mouth, *b*. A little lower than the head, there were fixed to the thorax ſeveral particles in two arrangements, twelve on a ſide, very much reſembling, in form, the little fimbriated appendages already mentioned; which I here repreſent as riſing from the ſides of the body, *c c*. I obſerved, that the little Frog could expand theſe particles at pleaſure, and draw them up towards the abdomen, and afterwards reduce them to their former ſituation. The diviſion of the thorax and abdomen was pretty diſtinct. In the belly lay an inteſtine, which ſwelled beyond the external ſurface; and, tho' not completely coiled, formed a great variety of windings in its way to the root of the tail, where it at laſt ſeemed to terminate, *d*. The *e e* tail on each ſide was ſomewhat tranſparent, but more opake in the middle, owing to its being thicker thereabouts, and to its having alſo there a great many cartilaginous parts, each furniſhed with its peculiar muſcles for moving the tail. I could therefore plainly diſcern, that this cartilaginous and muſcular portion of the tail, extended to its very extremity, *f*, in the midway between the two membranaceous lateral one. The ſkin of this young Frog, viewed with the microſcope, looked exactly as if it was thick ſet with black ſpots, upon a lighter ground, which appeared in their interſtices.

On my diſſecting this animal, and opening its abdomen for the firſt time, the inteſtine appeared very conſpicuous; but ſo delicate, that, with the ſlighteſt handling, it diſſolved into a great many globular particles; as did likewiſe the appendages, which were diſpoſed with great art, like beautiful round ſpots, on each ſide of the thorax. Even the ſkin itſelf, when handled, fell into particles of the ſame form. I could not diſcover the ſtomach, on account of this wonderful tenderneſs of the animal's internal parts. I thought, indeed, I ſaw the heart; but I could not perceive either blood or veſſels. The contents of the thorax fell alſo into little globules, in the ſame manner with the other parts already taken notice of. The eyes exhibited themſelves much more diſtinctly within the head, than in its outſide. The cartilaginous rudiments of the tail were grown to ſuch a degree of firmneſs, that I could but juſt ſeparate them from the adjacent parts. Tho' the tail moved about pretty violently, I could not clearly notwithſtanding diſcover its muſcles, as well becauſe they were extremely minute, as becauſe the ſame wonderful fluidity and ſpherical configuration ſhewed itſelf in the parts of theſe organs of motion. However, I could plainly perceive them growing in another little Frog, near the root of the tail. The colour of the animal's internal parts was a dark gray. This proved another obſtacle to my anatomical inquiries, by cauſing, in all their appearances, an immediate confuſion. I could diſcover nothing more than I have already mentioned in ſome of theſe Vermicles of Frogs, which I had ſet apart as larger, and conſequently fitter for diſſection than others. I could only obſerve, that thoſe round particles or grains, of which I ſaid, at my ſetting out, that the eggs conſiſted, went likewiſe to compoſe the ſkin and internal parts of the Frog. A circumſtance that could not fail of ſurpriſing me greatly, and the more ſo, as they were conſiderable and diſtinct enough to be ſeen with a common microſcope.

At this time, namely, on the 2d of May, I caught a Frog, which had not as yet diſcharged her eggs; for which reaſon I opened her, and fed with them my young Frogs. This animal's miſſing the uſual ſeaſon for this operation, might be owing to her wanting a male, or to her being in a ſickly condition. Be that as it will, her eggs did not unfold themſelves on being thrown into the water, like the others.

On the twentieth day of theſe experiments, which was the 7th of May, the fimbriated appendices, Tab. XLVIII. Fig. XII. *cc*, had begun to diſappear; and were no more to be ſeen on one ſide of a Frog, ſomewhat bigger than the reſt. This made me eager to inveſtigate the cauſe of ſuch a change, eſpecially as the appendages of the left ſide, which had not as yet totally vaniſhed, ſtill continued in motion. In the courſe then of my inquiries for this purpoſe, I obſerved, that the ſkin of the body, which lay between theſe particles, had grown over ſo as to cover entirely that of the right ſide; and had already begun to take in, after the ſame manner, the particle on the left. I afterwards diſcovered, that the two particles I have exhibited as lying on the animal's thorax, under its head, with a direction downward, had each of them a paſſage to that part under the ſkin, which appeared to extend towards the fimbriated appendages; but I could not be ſure of this circumſtance, on account of the extreme tenderneſs of all theſe parts in the young Frog. However, I hence, with great reaſon, ſuſpected that theſe particles might afterwards poſſibly grow into the young Frog's branchiæ; for I alſo obſerved, that the particle, which the ſkin had already over-run on every ſide, had likewiſe loſt ſomewhat of its original appearance and form.

The protuberant inteſtines might now be more eaſily diſcerned; and their termination, at the place already mentioned, Tab. XLVIII. Fig. XII. *d*, was become much more conſpicuous. The pulſations of the heart, at this period very ſtrong, were likewiſe very viſible through the tranſparent ſkin *. In the tail the cartilaginous vertebræ, and the muſcles fixed to them on each ſide, ſhewed themſelves very diſtinctly, and, in a beautiful manner, reſembled a gooſe-quill branching on both ſides into ſmaller feathers; for thus, nearly, thoſe muſcles hung to the cartilages which they were to move.

In diſſecting the little animal, I found its inteſtines were increaſing every way by degrees, but in length eſpecially; to favour the increaſe this way, they were rolled up into coils, on account of the ſhortneſs of the body in which they lay. But they were, however, as yet tender, and their external coats ſtill conſiſted of little globules. I could now juſt diſcern the ſtomach, as likewiſe the liver and gall-bladder of an aqueous or watry colour, and compoſed likewiſe of ſpherical particles. The entire liver conſiſted alſo of grains of the ſame form, and the very heart itſelf, which I took panting out of the body, and at every ſyſtole uſed to fill with thoſe grains, the little tide of whitiſh blood it drove into the arteries.

Upon the whole, it was manifeſt, that the heart was formed in the little Frog, in much the ſame manner with that of Chickens, according to the account given us of them, by that illuſtrious anatomiſt, Marcellus Malphigi. The blood-veſſels alſo, now ſhewed themſelves. The eyes, and all their humours ſtill conſiſted of little globules; as did even the black part of the uvea. The mouth, contracted like the mouths of Fiſhes, was grown a great deal more wide and ſpacious, tho' not ſo large in proportion, by many degrees, as that of a Frog, arrived at its full growth; or even of a young Frog that has juſt thrown off its tadpole ſkin; as ſhall be illuſtrated with a figure in its proper place. As to the particles which formerly lay on the outſide of the thorax below the mouth. I could no longer ſee any thing of them; nor have I made any other obſervations concerning theſe appendages, beſide thoſe already mentioned.

May the twenty-third, which was the twenty-ſixth day after the young Frogs had left their white ſubſtance, I received a ſupply of little Frogs from the country, in a flat-bottomed earthen pot.

Having before diſſected all thoſe that I had hatched and and raiſed myſelf, leſt the little animals ſhould be killed in the paſſage by the continual toſſing of the water; and in order to afford them reſting places, I ordered, by way of preſervation, that the pot ſhould be nearly filled with duckweed: and have with this ſoft matter, only a little water. This contrivance anſwered ſo well, that I received all the Frogs in good condition. The ſmalleſt ſpecies of them was of the ſize exhibited in thę the thirteenth figure, Tab. XLVIII. Fig. XIII. and theſe were the Frogs I now took under my conſideration, as I had ſet out by conſidering thoſe of the ſmalleſt kind. This pot contained a good many Frogs of twice the ſize of the former, but they were the offspring of a larger ſpecies; ſo that I only made uſe of them to obtain better notions concerning ſuch parts of the animal, as I had before diſcovered them in the ſmaller ſpecies. It is now time to deſcribe the many curious things that occurred in the courſe of my ſuperficial ſurvey and anatomical inquiry.

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* No creature affords more entertainment or inſtruction, by the microſcope, than the Frog. The animalcules in the ſemen of the male we have already mentioned. The circulation of the blood is ſeen in the meſentery, by the help of the ſolar microſcope, more beautifully than in any other creature.

The firſt thing that appeared worth notice, without diſſection, was the wonderful contrivance and conſtruction of the mouth, Fig. XIII. *a*. But as theſe parts of the young Frog are too ſmall to be properly repreſented in figures of their natural ſize, I ſhall rather exhibit them as they appear thro' the microſcope, on laying the creature upon its back, with its viſcera ſeparated one from another. The external opening of young Frogs mouths, is by no means placed in the anterior extremity of the head, as it is in moſt Fiſhes, and even in grown up Frogs, but opens in the thorax a little deeper under the head, as in the Shark, ſo that the young animal is obliged to turn itſelf on its back, in order to ſeize any thing that floats upon the ſurface of the water; and I have often ſeen it throw itſelf into this poſture, either when it happened to be very hungry, or intended to diſcharge the air from its lungs: upon theſe occaſions, it turned ſo nimbly, that my eye could ſcarce follow it.

The aperture of its mouth conſiſts of an under jaw *a a*, Tab. XLIX. Fig. I. and a upper one *b*, both moveable, of an extreme blackneſs, and armed with very ſmall teeth like a ſaw, with which, conſidering its ſtrength and ſize, the little animal is able to bite exceeding hard. Theſe parts ſeem to be made of a ſlender, horny, and pretty flexible bone. There are, moreover, both above and below the opening, a great many little horny bones of the ſame kind, furniſhed with a multitude of little black teeth. All theſe little bones are placed upon ſome muſcular and very white plaits, which ſerve the animal like ſo many lips, and ſhut its mouth, or keep it ſhut; they firſt ſeize the prey it aims at, and then help it to draw gradually into its mouth the food it has taken hold of: for this reaſon the young Frog can move open and cloſe all theſe muſcular parts in a great variety of ways. The ſkin lying on each ſide beneath the mouth, conſiſts of a great number of white papillæ *cc*; ſo that it affords in the Frog itſelf a very beautiful appearance. A little lower down are the protuberant eyes *dd*. The ſkin that covers theſe and every other part of the body are moſt neatly coloured like variegated marble with gold ſtars and ſpots as it were upon a black ground. This animal, when turned ſo as to lie on its back, ſhews on the forepart above the eyes, its noſtrils, thro' which it breathes, lifting the head for that purpoſe, a little above the ſurface of the water; and on this occaſion it moves thoſe parts, which it alternately expands and contracts, in a very elegant manner.

On opening at this time the little animal's thorax, there appear very diſtinctly in this part, and a little below the place where the bone of the breaſt grows, the branchiæ, or gills, divided on each ſide into four primary orders, or rather ranges *ee*. We may even ſee how each of theſe orders is again, as it were, ſubdivided into a great many globular prominent parts, along which the blood-veſſels run in vaſt numbers, and in an uncommon and very beautiful manner. At the ſame time the lungs are alſo ſeen lower down in the abdomen *ff*, and they are almoſt always found ſwelled with air, in the manner I have repreſented the right portion of them; where I have likewiſe taken occaſion to exhibit the blood-veſſels diſpoſed over this organ. The left portion is repreſented as it appears when collapſed; for then there remains in it but a very inconſiderable portion of air, which, on account of the extreme delicacy and tranſparency of the membranes conſtituting the pulmonary lobes, appears no otherwiſe than as a naked bubble of air, lying externally on the part whoſe continuation really encloſes it.

This is a moſt curious obſervation, as it informs us there is an animal, which, at one and the ſame time, has both gills and lungs, both ſerving to circulate, cool, alter, and purify the blood. It is probable the air, in this creature, mixes with the blood in its paſſage through the lungs; and that afterwards, in company with this fluid, it viſits every part of the body; whilſt the water, by paſſing thro' the mouth at the gills, has at the ſame time the very ſame effect.

Theſe gills are no other than the little fimbriated appendages, which I repreſented bigger than the life, in Tab. XLVIII. Fig. XII. as hanging on the outſide of the body; and which, on being taken in by the creature in its growth, are now advanced to the important office of gills. It is in this manner exactly, that the vitellus of the Chicken, which at firſt lies without the abdomen, comes afterwards by degrees to be ſhut up in the belly, as Dr. Steno firſt deſcribed this natural proceſs, which he likewiſe illuſtrates with an accurate figure; and immediately after him, that curious Engliſhman, Walter Needham: for theſe two gentlemen, who were quite unacquainted with each other, made this diſcovery at the ſame time, in different countries. Theſe borders or edgings are very diſcernible on the little Frog's firſt appearance from within its albumen, and while they continue on the outſide of the body. The learned Oligerus Jacobæus was acquainted with theſe particles, as appears by his being the firſt who gave a figure of them, with a ſhort explanation, in which he juſt takes notice of their diſappearing in time; but this circumſtance might be eaſily known, and without the help of diſſection, and I took notice of it myſelf more than twelve years ago. The gills heretofore deſcribed, may be likewiſe ſeen within in the Frog's mouth, through which the water flows upon them, and is then diſcharged, after altering the blood that paſſes through theſe organs.

Nor could I ever yet diſcover, that theſe branchiæ or gills, have any openings on the ſides of the body, as is uſually the caſe in fiſhes.

Here it may be probably aſked, whether the blood circulates in the young Frog, both through the gills and lungs? This I cannot abſolutely determine; for whilſt I was engaged in theſe obſervations, I was diſturbed with the caſes of many who were dangerouſly ſick, which prevented my having time and leiſure for examining this matter in the largeſt young Frogs, one of which I have repreſented, Tab. XLVI. under No. V. otherwiſe I had reſolved to render theſe obſervations on the generation and change of young Frogs as complete as poſſible. I muſt therefore deſire the reader to accept what I now exhibit on this ſubject, as the prelude only of a more perfect work, to be hereafter publiſhed. Though I have already obſerved many things concerning this matter, I have not ſuch confidence in my memory, as to preſume to publiſh, before I reexamine them.

In order to make ſome anſwer from my former obſervations to the queſtion I have juſt now propoſed, I am thoroughly perſwaded, that the greateſt part of the blood circulates in the young Frog through the gills; and that only a ſmall part of it is conveyed through the lungs; and this deſigned probably only to nouriſh them, and to ſupply the remaining maſs of blood with air. The reaſon why I propoſe this opinion is, that only a very ſmall portion of the blood circulates thus in full grown Frogs, in which the gills, being probably thrown off with the laſt ſkin which the Tadpole caſts, wholly diſappear; and, on the other hand, the greateſt part is after this diſtributed into the whole body, out of the heart through the arteries, without touching the lungs. This is made evident in a letter, which I formerly wrote to the celebrated Oldenburg, ſecretary to the royal ſociety of London, and which is to be found in the philoſophical tranſactions of that ſociety. I hope alſo, that by this obſervation, I have at length proved it, againſt the opinion of the famous Malpighius and Needham, who think the blood is perfected in the lungs; that ſanguification, or the making of blood, muſt be wholly attributed to the liver. I am perſuaded, that I can demonſtrate it very eaſily: though ſome, ſtimulated with envy and vain glory, bark againſt it, like dogs againſt the glittering brightneſs of the moon. My experiments concerning this matter, indeed, penetrate further than any perſon hath ever probably thought. But I return to the Tadpole or young Frog.

The heart, Tab. XLIX. Fig. I. *g*, is placed between the gills in the Tadpole; and out of it, one may very diſtinctly ſee produced the great artery: this is divided into two branches; and theſe are further divided into very conſpicuous ſprigs or ſhoots, which have all gills annexed to them: but whether ſome of thoſe branches are likewiſe tranſmitted to the lungs, as is the caſe in full grown Frogs, I could not at this time, for the reaſons beforementioned, examine: I am ſtill doubtful alſo, whether all theſe ſhoots are diſtributed to the gills alone.

Near the heart is placed the auricula *h*, which has not yet ſuch a ſituation or figure, as it has in full grown Frogs. But in the examination of the auricula, and its veſſels, I have not yet arrived ſo far as to ſatisfy myſelf: therefore, I cannot exactly declare, whether thoſe two veins, which I delineate under the Auricula, reach to the gills, and carry back the blood from them to the heart, or whether they communicate with the veſſels of the lungs. All theſe matters ſtill remain to be inquired into. But for this reaſon, I do not ſcruple to delineate thoſe parts, as they appeared to me, without examining them more exactly.

Below thoſe two veins is ſituated the vena cava and liver, *i*; this I obſerved to be divided, as it were, into four lobes: it is at this period whitiſh, and ſomewhat rediſh. It is plainly diſcovered, that the liver is compoſed of very regular glandulous granules, which one may take for very ſmall glands. Near the liver in the Tadpole is placed the gullet, *k*, which deſcends from the mouth to the ſtomach, and is delineated here in that form. But, in order to avoid confuſion, I delineate the gall-bladder, *l*, near the other ſide of the gullet. That little bag of gall was at this time of a white, diaphanous hue: nay, the bile itſelf was limpid and perſpicuous, and without any bitterneſs; though in the full grown Frogs, it is ſometimes ſo green and fluid, that it may be uſed to draw lines. The fluidity of the gall ſeems to me to depend on its piercing bitterneſs, which is manifeſt ſome months afterwards, if paper, rubed over with ſuch gall, be put into the mouth. The ſpleen in the Tadpole is very ſmall, triangular, but ſomewhat irregular, and much more red than the liver: this is likewiſe the caſe in full grown Frogs.

There was nothing more beautiful to obſerve in this diſſection, than the courſe of the gullet, ſtomach and inteſtines; for theſe parts were obſerved to be very admirably convoluted in the body of the Tadpole. The firſt ſinus, into which the gullet was twiſted, was about the liver, Tab. XLIX. Fig. I. *m*, under which I have delineated, *n*, a certain portion of the meſentery, together with its blood veſſels. The ſtomach was in the beginning, and in its ſtate of accretion, like a piece of red fleſh, which being partly ſituated over the gullet and ſmall guts, began *o* to ſwell and grow thick. But there was likewiſe obſerved a great number of blood veſſels, which diſtributing themſelves through the ſtomach, formed as it were a beautiful net.

I here diſcovered moſt clearly, that the ſtomach in the beginning of the young Frog's accretion, did not yet perform its office, which was in the mean time performed by its gullet and inteſtines, which were for that reaſon made proportionably larger and longer in the young Frog, than even in the full grown one. On meaſuring the length of the inteſtines in this little creature, I obſerved it to be five inches. When I thoroughly viewed the contents of the gullet, ſtomach and ſmall guts, I obſerved they were all of the ſame nature, and contained ſome parts, of aquatic plants, little grains of ſand, clay or mud. Therefore, when I fed theſe young Frogs with Duckweed for ſome time in my chamber, in ſtone baſons, I obſerved that they eat all the roots of it ſo clean, that none remained; but not the round little part or leaf, which is full of air, and ſwims on the ſurface of the water. But afterwards, when they had nothing to eat under the water, I obſerved them continually rolling about on their back for hunger, and conſtantly catching the reſidue of the Duckweed in their mouth, though it was too big for them to ſwallow.

At the ſame time, I obſerved alſo, that the orbicular leaf of the Duckweed is not only full of air-bubbles, and for that reaſon neceſſarily floats on the ſurface of the water; but that even its very root of the plant, contains air, tho' not in a proportional quantity: this is probably the reaſon why the root ſubſides. I further obſerved, that the extremity of the peduncle, or root of the Duckweed, is thicker in proportion, and more porous than the ſtalk itſelf: and conſequently the nouriſhment ſeemed to me to penetrate through that extremity to the leaves. I likewiſe obſerved, that when I nurſed up one plant of Duckweed in a baſon of water, and expoſed it to the rays of the ſun, it inſenſibly put forth many roots; nay, that the very leaf of theſe little plants multiplied and increaſed into two, three, or four other leaves; the leaſt of which, afterwards ſeparating from the parent, formed ſeveral other ſmall ones; ſo that this little plant ſeemed to multiply itſelf without ſeed, in a very ſhort time. I had indeed reſolved, yet more accurately, to inveſtigate and delineate theſe things: but the reaſons before mentioned, have likewiſe diverted me from this reſolution.

Some years ago, examining the tubercles, which are found on the back of Fern-leaves, I obſerved that they conſiſted of ſome thin plates, or laminæ, in which the pods, containing the real ſeeds of the plant, were encloſed: though many authors deny that this, and ſuch like ſpecies of plants have any ſeed [*]. Since the art and ſtructure obſervable in theſe pods is admirable, I ſhall give a brief deſcription of them, until I have time to delineate them magnified; as I have formerly done to oblige Dr. Arnold Syen, profeſſor of botany, to whom I freely communicated this uncommon obſervation, ſince it regarded his profeſſion: of which, however, no further notice need be taken here.

Thoſe pods are of a round figure, and are compoſed, as it were, of two hemiſpheres, placed cloſe to each other; but they may be parted in the middle. About this joint or ſeam is beautifully twiſted a little herbaceous cord, which keeps the two ſegments of the pod in their ſituation. One extremity or baſis of this little rope grows to the fern-leaf; but the other is affixed to the lower hemiſphere of the pod; and at length, after ſurrounding the whole pod, it terminates in the upper part of it.

In the cavity of this pod the Fern-ſeed lies, and it is indeed ſo ſmall, that it is with great difficulty to be diſcerned by the naked eye; and when blown upon, it vaniſhes into the air like fine duſt.

But this is only a ſmall part of thoſe beauties that are obſerved about the pod, and its cord. I beg leave to obſerve from hence, that when the ſeed grows ripe on the inſide, and the pod dries away, then the cord, twiſted round the pod like a rope, is ſo ſtrongly curled, on account of its contorſions, that it makes the pod fly into two parts, and forces a paſſage for the ſeed to diſperſe itſelf.

This may be ſeen clearly and diſtinctly, if the ſeed be examined in autumn with a microſcope: for as the head is, under this inſpection, very near this ſeed, I have often obſerved, that a great number of theſe pods, burſt aſunder by force of the twiſted cords, which are contracted by the breath and heat of the body, and the ſeed, is by this means thrown out. But theſe things are only ſaid occaſionally in this place [†].

The pancreas in the Tadpole was obſerved, Tab. XLIX. Fig. 1. *p*, to be ſituated near the ſtomach, and compoſed of diſtinctly conſpicuous glandules. Below the ſtomach appeared *q* the ſmall gut, with its blood-veſſels and contents, which were of a greeniſh tranſparent colour. But the convolutions of the inteſtines exhibited the moſt beautiful ſight of all; for theſe were orderly and regularly rolled *r r* into two diſtinct ſerpentine forms. One of their extremities was joined to the rectum, *s*, which at length conſtituted the fundament between the two hinder legs, *t*. The difference, however, between the ſmall and great guts was not very conſiderable in the Tadpole; nor is it very remarkable in the human fœtus, in which there is, at firſt, very little difference between the ſmall gut, colon, and rectum; as I can demonſtrate in a human fœtus ſix months old.

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[*] Every part of natural hiſtory is greatly improved of late time. This author firſt diſcovered the ſeeds of Fern, unknown to former writers; and we have ſince diſcovered thoſe of Duckweed, which were unknown to him. This little plant is now known to produce its like in the manner of all others. Small as the whole plant is, it produces flowers of all kinds from the ſame root. In ſome of them are the filaments, two in number, and a ſingle ſtyle riſing from a ſmall oval rudiment of a fruit: in others, there are no filaments, but only the rudiment of a fruit with its ſtyle. The cap which contains theſe, is alike in both kinds; it is rounded, and ſplits on one ſide: there are no petals in either flower. The rudiment of a fruit decays, and comes to nothing in thoſe flowers which have the filaments with it; but in the others it becomes a globous ſeed veſſel, terminated by a point, and contains ſeveral oblong ſeeds. This is eſtabliſhed on the opinions of Micheli, Dillenius and Buxbaum, and is confirmed by Linnæus, and by experience.

[†] The world owes great acknowledgments to this author for many diſcoveries; and he with juſtice claims that diſtinction, in regard to the ſeeds of Fern, of which he treats more largely hereafter. The ſcience of Botany is ſo far improved ſince his time, that we have diſcovered diſtinctly the ſeeds, and their peculiar diſtribution on the leaves, in all the capillary plants. In Oſmund they are encloſed in diſtinct globular capſules, which burſt ſideways; in the Louchilis they are laid in lines, like creſcents, under the hollows of the leaves; in Hartſtongue and Trichomanes they are diſpoſed, in ſtraight lines, under the diſk of the leaf; in Polypody they are arranged in round dots; in the true Maidenhair in oval aſſemblages, at the tips of the leaves: the Horſetail has them in oval ſpikes; and the Adderſtongue in cells, placed in two rows along the ſpike. Theſe plants are now found to belong diſtinctly to the four kinds; and in the Rutta Muraria they cover the whole under-part of the leaf.

The moſt remarkable thing in this little animal was, that only the rudiments of *u u* the two hinder feet of the Frog were yet ſeen; and from them the toes, not yet ſtrengthened inwardly with bones, began to ſwell, as a branch does out of a tree; though the figure and conſtruction of the feet was, however, pretty perfect and evident. But as to the two fore legs, not even the leaſt veſtige of them yet appeared outwardly, becauſe they lay *x x* hidden, covered and encloſed under the ſkin: nor did they come in view before the ſkin was cut open in that part, and then they were ſeen ſituated above the lungs and below the gills, though they were not ſo perfect as the hinder feet.

It is evident, from what has been ſaid, that this animal may and ought to be conſidered, in its original, as a real inſect, ſince it hides its limbs under the ſkin, and theſe increaſe there until the change of the laſt ſkin is near at hand; at which time it is obſerved in inſects, that they are, as it were in an inſtant of time, transformed into other creatures, and exhibit to view ſuch limbs as they did not before appear to have. The ſame thing likewiſe holds in young Frogs or Tadpoles: wherefore this animal ought to be placed in the ſecond order or claſs of our natural changes, unleſs the juſt laws of method had commanded me to treat of it at the end of this work, in order to make the likeneſs between animals which have a red blood, and thoſe which contain white, yellow, or green blood in their heart and veſſels, the more evident.

As we ſee inſects loſe many parts with their old ſkin, this is likewiſe the caſe in the Frog; which, beſides other things, plainly caſts off its mouth and tail: ſo that, however admirable the art, order, conſtruction, and parts of its members may appear to be; yet the nerves, arteries, veins, cartilages, muſcles, and many other remarkable parts, which gradually vaniſh, and are, as it were, become inſenſible, are deſtroyed at once, ceaſe their motions, and ſtop their ſeveral functions, on the change. Are not theſe changes admirable? And do not they lay before our eyes the omnipotent hand of God, conſpicuous in his inacceſſible radiancy and infinite majeſty? He, in this caſe, forms another out of one and the ſame animal, which though different in appearance, yet remains one and the ſame creature. May not the reſurrection of the dead be exemplified in this illuſtrious inſtance? All this is very elegantly manifeſted in various inſects.

As the want of ſubjects now prevents my being able to inveſtigate further the moſt artificial compoſitions and changes of the limbs in the Tadpole, I ſhall here deſcribe only the muſcles, which are moſt regularly placed in the middle of the tail, and merit very particular notice. Thoſe muſcles are laid ſomewhat obliquely, and converge, Tab. XLIX. Fig. I. *y y y*, to each other from the two ſides of the tail towards the middle; and each of them is likewiſe divided into many moving fibres. That this may appear the clearer, I have delineated them as if they lay outwardly on the ſkin. On each ſide of the muſcles is ſeen *z z* the membranous ſkin of the tail, marked with beautiful points: by the help of this part the Tadpole moves its tail, and ſwims, ſince it uſes it like an oar, to puſh its body forward, with a ſerpentine motion.

Before I proceed to other obſervations, which I have made on the full-grown Frog, I ſhall give the method whereby the Frog changes its ſkin. I would have it obſerved, that I here treat of the largeſt ſpecies of Tadpoles, ſince the other kinds are much ſmaller. To which I muſt add, that I increaſed it a little above its natural ſize, in order to explain more intelligibly the metamorphoſis of the ſkin. The time when the young Frogs begin to caſt their ſkin, and to put on the form of a Nymph, is with us about the middle of June, or ſomewhat later; that is, a little more than two months after they come out of their eggs. When this time approaches, the ſkin of the young Frog is firſt uſually burſt in the back, near the head, and through this chink the young Frog immediately puts forth its head. Then is ſeen the mouth lying, Fig. II. *a*, in the Tadpole's exuviæ; and this is obſerved to differ much, *b*, from the wide opening of the Frog's mouth. Then the Frog turns out its firſt pair of legs, which lay till now hidden under the ſkin, *c c*, and at the ſame time it preſſes back the ſkin towards the hinder parts. Thus the reſt of the body, the hinder legs, *d d*, and alſo the tail, are ſtript of their ſkin: after which we ſee the tail contracted more and more every day, until at laſt no veſtige of it appears. If the Frog thus produced be a male, two pneumatic kidneys *e e* are diſcovered on each ſide of the head, behind the eyes; and the great toes of the fore feet appear alſo thicker and longer *f f* than in the female. But what parts in particular are left in the exuviæ, and whether the gills be diſcovered adhering to them, I have not yet examined. After the ſame manner Toads and Water-Newts caſt their ſkin.

Of the circulation of the blood in a full-grown Frog.

THE manner in which the blood circulates in the full-grown Frog, is not a point of ſmall moment: indeed, it very much recommends comparative anatomy, ſince, when that is not thoroughly known, it ſeems that one cannot arrive at the real knowledge of the uſe of the viſcera. The famous Malpighius, Needham, and many others, ſay that the Frog has viſible lungs and reſpiration. Nay, they alſo think that the blood circulates through the lungs, is there elaborated, leſſened in the globules, and brought to its full perfection: and hence the office of ſanguification, which, in former ages, was ſuppoſed to be done by the liver, is now transferred from thence to the lungs. Beſides, ſince the ſame gentleman has obſerved gills in Fiſh anſwering the purpoſe of lungs, thro' which all the blood circulates; and as they ſaw the water ſtrike againſt theſe in the manner as the air does againſt and into the lungs, in other animals, they have therefore made the gills perform the office of making blood.

I confeſs, this opinion is very ingenious; if it be ſuppoſed, that the liver does in no wiſe contribute to make blood. But from whence ſhall ſanguification be derived in this animal, which has lungs; but at the ſame time they are ſo circumſtanced, that the blood does not paſs thro' them, but is immediately diſtributed all over the whole body, out of the ſingle ventricle which their heart hath, without touching the lungs? This plainly is the caſe in Frogs. The ſame thing, probably, holds in Toads, Water-newts, Lizards, Chameleons, Tortoiſes, Serpents, and other creatures of that kind; all which I have obſerved to be provided with membranaceous lungs: tho' I have not yet accurately examined their blood-veſſels. We ſhall certainly be obliged to return to the liver, and reſtore it to its former degree of dignity. Nay, this holds more ſtrongly in the Frog, which is deſtitute of the lacteal veins: ſince its chyle muſt, for that reaſon, neceſſarily enter the great numbers of its meſeraic veins, and be thus conveyed thro' the vena porta to the liver. In the extremity of this vein, the blood, which is to paſs from thence into the cava, is broken and divided; and it ſeems to me to acquire its laſt perfection in the cava itſelf. As, I am confident, I ſhall, at ſome time, more fully demonſtrate, with reſpect to thoſe animals, which have lacteal veins. But I cannot now, for want of time, finiſh the experiments, which I have began, concerning this ſubject: and which, tho' not many in number, are yet ſo important, as to promiſe great diſcoveries.

Having premiſed theſe things, I ſhall now briefly deſcribe the principal arteries and veins in the Frog, and ſhall ſhew the manner in which the blood circulates thro' them. The Frog's heart, Tab. XLIX. Fig. III. *a*, as is the caſe in moſt Quadrupedes, is found ſituated in the cavity of the breaſt, which is indeed very ſmall. To the upper part of the heart, the auricle *b* is obſerved to be joined: but it has, like the hearts of Fiſh, only one ventricle, out of which likewiſe there iſſues only one artery; which is in the beginning conſiderably muſcular, and ſufficiently dilated, and immediately afterwards dividing into two trunks; one of which is detached to the right region *c*, the other to the left region of the breaſt *d*. Each of theſe arteries, which are like the ſubclavian veins, is further divided into three principal branches. The firſt of theſe, which is the leaſt *ee*, ſtretches on each ſide to the lungs, and gives them nouriſhment: and therefore I call theſe the pulmonary arteries, and they are of the nature of thoſe called Bronchials in man and brutes. Theſe, in their courſe to the lungs, are commonly divided into three branches, which I here exhibit as cut off; and after this ſtretching to the coat that ſurrounds the lungs, thereon form a very admirable piece of net-work, and communicate with each other by ſeveral anaſtomoſes: hence they alſo paſs down by very ſmall ſhoots, into the inward irregular veſicles of the lungs, among which the pulmonary vein is diffuſed, and with the latter they form a very conſpicuous anaſtomoſis, viſible even to the naked eye. This is manifeſt, if theſe veins and arteries be filled with quickſilver. I keep ſome prepared in this manner. Out of the pulmonary arteries likewiſe proceed two ſmall branches, Tab. XLIX. Fig. III. *ff* on each ſide, turning upwards, which are diſtributed thro' the parts of the mouth.

The ſecond pair of the principal branches, ariſing out of the trunk of the great artery, are obſerved to be dilated into two remarkable ſwollen knots; theſe are of a grayiſh black colour *gg*, in the living Frog. Both theſe arteries are after this extenuated, and, together with the little branches iſſuing from them, ſeem deſigned only to ſerve the muſcles of the mouth, and thoſe of reſpiration. But as each of them aſcends higher, it is again dilated into a knotty little bladder. I ſhould think theſe arteries are duplicates of the nature of thoſe which before ſerved for conveying the blood to the gills. This I cannot affirm for certain; but it may be hereafter examined into by repeated diſſections.

The third pair of the primary branches are particularly worthy of conſideration; ſince theſe properly conſtitute the trunk of the arteria magna in the region of the loins, and are there for that purpoſe united by a very conſpicuous anaſtomoſis. They riſe out of the trunk of the arteria magna, then they bend *hh* circularly under the lungs; and, after ſending out ſome branches, they likewiſe emit *ii* the axillary arteries from off their ſides. We obſerve, that a little deeper beneath the heart, the carotid arteries ariſe from them; and that theſe aſcending *kk* from thence towards the head, bury themſelves in the bones of the ſkull. The arteries of the vertebræ, alſo ariſe *ll* from theſe branches; and at length uniting together by a manifeſtly conſpicuous anaſtomoſis, they conſtitute the trunk of the loins; out of which riſes the cæliac artery, which afterwards ſends out from it *m*, the meſenteric artery. Some arteries alſo, as thoſe of the loins *nn*, and thoſe that are detached to the teſticles, ovary *oo* and reins *p*, have their origin from the ſame trunk; and this ſame trunk is itſelf afterwards divided in the laſt place into the iliac *qq* branches.

The blood being driven out of the heart through all theſe arteries, to the circumference of the body and viſcera, at laſt returns by a manifeſt circulation through the veins to the heart, as to its center; whilſt in the mean time only a part of it circulates through the lungs, and indeed exactly in the ſame manner in which it circulates through the muſcles and the reſt of the viſcera. Therefore, the blood in the Frog circulates in a quite different order, than is obſerved in other animal quadrupedes, or in fiſhes; in which all the blood paſſes either thro' the lungs, or thro' the gills: that is, the upper trunks of the vena cava, which are united to the auricle of the heart, and are here delineated under both trunks of the great artery, do not in the Frog deduce their blood from the lungs; but they imbibe it directly from theſe veins, which run in the upper part of the body, and from ſome others that are ſituated next to the ſkin in the ſides lower down, and they likewiſe get a ſmall portion, that returns from nouriſhing the lungs. The blood, on its return from the lower parts of the body, does not touch the lungs, but diſcharges itſelf thro' the porta and cava, into the auricle of the heart, without coming near the lungs. Therefore, by inflating only one vein of the Frog's body, the arteries may be all inflated alſo.

The diſtribution of the Veins differs here conſiderably from that of the arteries; for the two trunks of the the cava, are conſpicuous above at the auricle, Tab. XLIX. Fig. IV. *a a*, where I have opened *b*, the arteries, emit pulmonary veins out of their lower ſide, (here cut off) *cc*, which are twice as large as the arteries. Theſe veins are properly placed in the cavity of the lungs, and particularly in the extremities of the pulmonary veſicles, and in the loins; and they diffuſe their capillary, and almoſt inviſible branches all over the cells; nay, even thro' the coat which inveſts them. Here, therefore, in the lungs of the Frog, a conſiſiderable blood-veſſel, namely, the arterial vein, is wanting: the animal has no need of this artificial canal; ſince Nature did not intend that all the blood ſhould paſs thro' the lungs. Beſides, the two upper trunks of the cava paſs above the arteries in the Frog, and are alſo divided into various branches. Some little veins are from thence detached *dd*, to the parts about the mouth: others, which bend very beautifully in their paſſage, go towards the head *ee*, and give a part of themſelves *ff*, to the muſcles of the firſt pair of legs. The axillary veins alſo, ſpring *gg*, from the ſame trunks, and emit two very conſiderable *hh* branches, which in the ilia beautifully bend themſelves back under the ſkin above the muſcles of the belly; and from thence aſcending again towards the thorax, and being there conſiderably dilated, they communicate, by a mutual anaſtomoſis, with the reſt of the veins that are ſituated about theſe places. The trunk of the cava, which is ſituated beneath the heart, is ſimple *i*, and is there divided into three branches, which are diſperſed thro' *kk* the liver. A little lower, the meſenteric vein riſes *l* out of the liver: under which the trunk of the cava very beautifully diffuſes *m* itſelf, by many branches over the kidneys; and at length, after dividing into two parts, conſtitutes the iliac *n n* branches, from which the epigaſtric vein is obſerved to riſe *o o* very beautifully. This vein goes back along the ſtraight muſcles into the liver; where I repreſent it cut off. But if this little veſſel, and all the integuments of the belly, be diſſected near the liver, and then turned above the hind legs; all the veins of the body may be conveniently inflated through it. By this means veins are diſcovered in the liver, the kidneys, and all the viſcera. And from thence I took an opportunity of making, with very little labour, the following very remarkable experiments. Let what hath been hitherto ſaid, ſuffice in regard to the circulation of the blood, and the blood-veſſels in the Frog.

Having finiſhed the obſervations now recited, as quick as poſſible, I afterwards examined ſome muſcles, and alſo the ſkin, eyes, and blood of a full-grown Frog. I found it eaſy to divide the moving fibres of the muſcles ſo ſmall, that they reſembled a Spider's web. But when I put them divided in this manner under the microſcope, I found they conſiſted of ſtill ſmaller fibres, and thoſe of very minute globules. I firſt diſcovered the epidermis in the ſkin; it ſupported the real ſkin, the latter being adorned with beautiful colours and black ſpots, and appearing compoſed, as it were, of globules. I further ſeparated the ſkin into a glandular ſubſtance, which was compoſed of very numerous globular glandules. Thoſe glandules ſecreted that viſcous or ſlimy matter, which is obſerved to be ſpread over the ſurface of the Frog's ſkin, and rendered the latter very ſmooth and ſlippery. This ſpecies of mucous matter taſtes bitter, and offends the eyes with its acrimony; nay, it cauſes a ſenſible pain, if rubbed to our ſkin when wounded a little; ſo that we muſt be cautious in the uſe of it. I next examined the aqueous humour of the eye in a glaſs tube; but I perceived nothing more than the clearneſs of the liquor. And hence, then putting both extremities of that tube to a lamp, I boiled that and the whole Frog's eye in water: but there were no globules conſpicuous in it from this proceſs. Both the white part of the cryſtalline humour, which reſembles chalk, and ſurrounds it, and the other fibrous diaphanous portion, which is divided into ſeveral lamellæ or plates, conſiſted entirely of globules. I ſaw a ſerum in the blood, in which were a vaſt number of orbicular particles, of a flat oval but regular figure. These particles ſeemed alſo to contain another fluid: but when I viewed them ſideways, they reſembled cryſtalline clubs, and ſeveral other figures; that is, according as they were turned about in various directions in the ſerum of the blood. I obſerved beſides, that the colour of objects always appeared the more faint, the more they were magnified with a microſcope.

Experiments on the particular motion of the muſcles in the Frog; which may be alſo, in general, applied to all the motions of the muſcles in Men and Brutes.

HOW important and difficult it is to explain the real cauſes of muſcular motion, is ſufficiently evident from numerous experiments; which though made by very ingenious men, yet have not hitherto diſcovered its true nature. The great utility and foundation of further knowledge, which we ſhould acquire from that diſcovery, lie yet involved in the thickeſt clouds of obſcurity. This is the reaſon which now induces me to publiſh the experiments I made concerning the matter; which, as they ſeem to me to have great weight, and to contain ſome uſeful conſequences, I would therefore adviſe my readers to conſider ſeriouſly, and examine them by the touchſtone of truth.

In the conſtruction and motion of the muſcles, it merits particular conſideration, in what manner the nerve is actually joined to the muſcle; how it is conſtructed in the muſcle; what is its courſe, entrance, middle, diſtribution, and end; as alſo how it communicates with the moving fibre, and what effect it produces in it; alſo what that very ſubtle matter properly is, which is undoubtedly conveyed to the muſcle through the nerve. The knowledge of all theſe particulars is not ſufficient for our purpoſe: one muſt likewiſe know the conſtruction of the membranes, that inveſt both the ſurface of the muſcle and its inward parts, and the delicate leſſer fibres that reach from one moving fibre to the other, and, like a very fine web, diffuſe themſelves through the interſtices of the latter. It would be likewiſe neceſſary to know the ſtructure of the vein and artery belonging to the muſcles, and their real conſtitution or diſpoſition in the muſcle, and to underſtand accurately what belongs to the compoſition of the moving fibres. But all theſe things are ſtill obſcure and unknown, and will not be probably diſcovered till we employ all our time, and the greateſt diligence, in inveſtigating them: but all difficulties are conquered by induſtry, and an unwearied application. As to myſelf, I candidly confeſs, that I have not brought every ſubject, which I have advanced, to the greateſt perfection poſſible; for, in order to attain this, I ſhould have ſpent my whole life in diſcovering one thing, and this courſe is not agreeable to me: for I am thoroughly perſuaded, that, if I came to the utmoſt extremity, I ſhould at laſt diſcover nothing but my own ignorance. For this reaſon, I thought it better to employ my time rather on various things than on one; leſt, whilſt I was too intent on a thorough knowledge of one or two particulars, many of God's work ſhould lie hidden from me: for, indeed, all the knowledge we are capable of, conſiſts only in this, to love God as we ought.

With reſpect therefore to all the ſubjects hitherto recited, I ſtill find many indiſſoluble difficulties. And though the excellent anatomiſt, Dr. Steno, hath diſcovered many curious things relative to this matter, yet he ſtops alſo in the middle of his courſe. Beſides, how far are we from knowing the motion and effect produced by the ſubtle ſpirit, that continually paſſes through the nerves into the muſcles! This matter lies buried in impenetrable darkneſs. Since I have made many experiments, at different times, on the motion of the muſcles, I ſhall now, however, ſet forth the chief of them, and ſubmit them to the examination of the learned.

It is a matter eternally certain, and of greateſt moment, that whenever the nerves of living bodies are handled, there is immediately obſerved a conſiderable motion in the muſcles to which they are ſent, and this motion does not at all differ from the contraction of thoſe muſcles. If we lightly pinch or prick the nerves of the diaphragm in a living dog, opened for the experiment, with the point of a very fine needle; or if we ſtimulate them by putting them near the fire, or by pouring acrid liquors into them; we immediately ſee the diaphragm performs its natural function: it contracts itſelf, from being arched becomes ſmooth, raiſes itſelf from the thorax, puſhes out the viſcera of the abdomen, and the cavity of the thorax is enlarged in proportion as the diaphragm contracts itſelf and becomes more ſmooth, and is more ſtretched out of the breaſt.

This experiment is very fine and elegant, ſince the motion alſo, which is then obſerved in that compound muſcle, appears admirable; and the ſame experiment may be often repeated in the ſame ſubject, if the nerves of the diaphragm be firſt irritated, where their beginnings run near the pericardium. In order to irritate them a ſecond, third, and fourth time, we muſt deſcend by degrees, and chooſe a lower part of them, until we come to the very place where they are inſerted in the diaphragm.

This experiment on the nerve may alſo be very eaſily made, not only in this but all the other muſcular parts of the animal's body, with the ſame ſucceſs. Hence we often obſerve, on diſſecting living animals, that when the nerves are wounded with a knife, conſiderable motions ariſe in the muſcles to which they belong. This the celebrated Steno hath likewiſe obſerved in his Myolog. Specim. p. 78 and 79, after I had ſhewn him my old and common experiment on Frogs. This is obſerved to happen not only in quadrupedes, but in birds and fiſhes, but eſpecially in the Wray-fiſh; in the muſcles of which there are very ſtrong motions, when the nerves are irritated.

On the foundation of theſe motions, which are produced in the muſcles, when their nerves are only diſturbed or ſtimulated, I determined to provoke the nerves of the entrails in the ſame manner, in which I found very remarkable fleſhy fibres. I had a mind to make the ſame experiments on thoſe nerves which reach to the kidneys, liver, ſpleen, lungs, and genital organs; for I would ſcarce preſume to affirm, that any remarkable contractions are produced in thoſe parts, eſpecially in the kidneys, by ſuch irritation; and therefore one may penetrate much deeper, by that experiment, into the real uſes of theſe parts. But I have not yet been able to execute my purpoſe, for want of time. It is therefore ſufficient for me here to have hinted at theſe things in a few words, that others may have an opportunity of labouring further in the diſquiſition of them; for Nature muſt be inveſtigated by the joint labours of many. One man can make no great advancement in matters infinite.

I beg leave to obſerve here, that the motions of the muſcles, now mentioned, are not ſo conſiderable in animals which have warm blood, or rather they do not laſt ſo long, as in thoſe that have the blood cold; as fiſh, and many other aquatic creatures, which have few or no feet, and in amphibious creatures in general. Hence I chiefly made my experiments on the Frog; for the nerves are very conſpicuous in theſe animals, and may be eaſily diſcovered and laid bare. The ſpinal marrow and the brain have this peculiarity in the Frog, that, like a fluid ſalt, they lie encloſed in coats, and, being interwoven with blood-veſſels, are every where adjacent to them; ſo that they are to be diſcovered plainly even in the cavity of the vertebræ, and in the ſkull. The ſpinal marrow glitters like pearl, and is diſpoſed, in the form of knots, all down the back, along the vertebræ, where it appears very conſpicuous. This native ſalt, mixed with an acid liquor, ferments very ſtrongly. Its ſubſtance anſwers very nearly to that granulated and gravelly powder found in the head of the Shark, and ſold in the ſhops, and erroneouſly taken by the ignorant, for the brain of the fiſh; but this is nothing more than a ſtony and gravelly ſubſtance, which is placed in the head of the Shark, as what is called the Perch-ſtone is in the head of the Perch. I have likewiſe found ſuch a powder in the Wray-fiſh's head, which fermented very ſtrongly with an acid: and, therefore, I think that the alcaline ſalt, obſervable in the little ſtones called Crabs-eyes, is like this. But though that ſaline ſubſtance in Frogs is fluid, like water, it will notwithſtanding be dried immediately by the heat of the hand or fingers; but it never hardens to ſuch a degree, but it may be very eaſily reduced to fine powder with the tips of the fingers. The ſame thing likewiſe holds with reſpect to that calcarious fluid matter in the Wray-fiſh. Whether this ſalt has any medicinal virtue, I cannot yet ſay; nor can it be known, except from experience. I return to the muſcles.

Another very delicate and uſeful experiment may be made, if one of the largeſt muſcles be ſeparated from the thigh of a Frog, and, together with its adherent nerve, prepared in ſuch a manner as to remain unhurt. For if, after this, you take hold, Tab. XLIX. Fig. v. *a a*, of each tendon with you hand, and then irritate *b* the propending nerve with ſciſſors, or any other inſtrument, the muſcle will recover its former motion, which it had loſt. You will ſee that it is immediately contracted, and draws together, as it were, both the hands, which hold the tendons. This I formerly (in the year 1658) demonſtrated to the moſt illuſtrious the now reigning Grand Duke of Tuſcany, when he graciouſly vouchſafed to pay me a viſit. This experiment may be repeated in the ſame muſcle, as long as any part of the nerve remains unhurt; and we can thus make the muſcle contract itſelf, as often as we pleaſe.

If we have a mind to obſerve, very exactly, in what degree the muſcle thickens in its contraction, and how far its tendons approach toward each other, we muſt put the muſcle into a glaſs tube, Fig. VI. *a*, and run two fine needles *b b* through both its tendons, where they had been before held by the fingers; and then fix the points of thoſe needles, neither too looſe nor too firmly, in a piece of cork. If afterwards you irritate, Tab. XLIX. Fig. VI. *c*, the nerves, you will ſee the muſcle drawing *d d* the heads of the needles together out of the places; and that the belly of the muſcle itſelf becomes conſiderably thicker *e* in the cavity of the glaſs tube, and ſtops up the whole tube, after expelling the air. This continues till the contraction ceaſes, and the needles then move back into their former places; and the belly of the muſcle, parting again from the tube, affords a free paſſage for the air through its cavity. But if the muſcle be left to itſelf, or put into cold water, with all the apparatus juſt now deſcribed, we obſerve it contracts itſelf by degrees not long after; and is finally ſo remarkably bent, as to fill the whole cavity of the middle region of the tube.

Having therefore duly conſidered thoſe experiments, which I have hitherto ſet forth, and at the ſame time attentively weighed the force of contraction or muſcular motion, which the muſcle reſumes every moment, when its nerve is again and again irritated: one may aſk, whether any other communication be neceſſary between the nerve and the muſcle, but only that ſimple irritation on the touch or commotion? But as a ſimilar motion is likewiſe excited in the muſcles of animals which have hot blood, whoſe nerves are ſtimulated; the ſame queſtion indeed may be likewiſe aſked here, that is, whether in this claſs of animals alſo, any other communication be neceſſary between the brain and marrow, the nerves and muſcles, except this ſtimulus? for I have conſtantly found, by all the experiments that I made, that the muſcles are contracted when the beginning of the marrow, or the nerves iſſuing from thence, are moved.

Hence I propoſe it, as a matter worth conſidering, whether we ſhould not reject that opinion, which ſuppoſes a ſpirituous matter to be neceſſary to excite muſcular motion, and that it flows out of the brain; and that this influx happens with ſuch great rapidity and velocity, that theſe new ſpirits conſtantly propel the former, and in an inſtant of time, at the leaſt intimation of the will, or otherwiſe ſpontaneouſly ſhould, and may, be in the moſt remote extremes of the body.

I am perſuaded, thoſe who derive the contraction of the muſcles from inflation, fermentation, or a kind of exploſive motion, will differ from me as to this matter: they will object, that the inflation or expanſion of the moving fibres, is evident even to the eyes, in the contraction of the muſcles; and beſides, that all the muſcular parts are filled with ſpirits: and therefore, that only a ſmall quantity of animal ſpirits is requiſite to inflate either theſe, or thoſe muſcles, and to expand them by contraction, as is evident to the ſight.

But all theſe opinions are certainly deſtroyed, if it be conſidered, how often the motion of each muſcle is reſtored by only ſtimulating, provoking, or irritating the nerve in my experiment before mentioned: and this, when the nerve hath been for a long time cut off, and the requiſite animal ſpirits diſſipated, or grown weak, after many times diſcharging their duty; and when there is no further communication between the nerve, brain, and marrow. Therefore, I would have it ſeriouſly conſidered, that it cannot be demonſtrated by any experiments, that any matter of ſenſible or comprehenſible bulk flows through the nerves into the muſcles. Nor does any thing elſe paſs through the nerves to the muſcles: all is a very quick kind of motion, which is indeed ſo rapid, that it may be properly called inſtantaneous. Therefore the ſpirit, as it is called, or that ſubtile matter, which flies in an inſtant through the nerves into the muſcles, may with the greateſt propriety be compared to that moſt ſwift motion, which, when one extremity of a long beam or board is ſtruck with the finger, runs with ſuch velocity along the wood, that it is perceived almoſt at the ſame inſtant at the other end; nay, that it is further propagated through the nerves into our muſcles; and thus produces various motions in them, as thoſe who attentively conſider this ſingular, though plain experiment, well know.

Add to theſe another argument of yet greater weight, which is, that the muſcles themſelves, when contracting, are not in the leaſt inflated or ſwollen, but rather they loſe their thickneſs; though the moving fibres in the mean time acquire a different ſituation; or, to expreſs the matter more exactly, they are preſſed cloſer to each other. We obſerve ſomething like this in a long piece of ſponge, made even and ſmooth, which becomes thicker and more ſolid by force of compreſſion; though in reality it poſſeſſes a much leſs ſpace. Therefore, for the many reaſons which ſhall be mentioned hereafter, I think it may be rightly inferred, that the ſhortening and cloſer compaction of the moving fibres, by reaſon whereof they are contracted into a leſs ſpace, is really the true action or contraction of the muſcle; and which is therefore erroneouſly called inflation, tumefaction, &c.

For what reaſon can any one imagine it poſſible for the muſcle to be inflated? ſince it conſiſts of ſuch ſubtile filaments, as are almoſt inviſible; though even theſe are finally compoſed of globules. What matter can effect this inflation? Is it not neceſſary, that it ſhould paſs through thoſe very fine fibrillæ, which conſtitute the nerves, and when curiouſly examined, without hurting them, are likewiſe ſo ſmall as to be almoſt inviſible? Certainly, if the nerves be conſidered to have their origin from the marrow, it is very evident, that they are ſo ſubtile there, and ſo cloſely ſurrounded by the meninges, that the ſmalleſt briſtle, or thread of ſpun glaſs, can ſcarce paſs through the aperture. How fine therefore muſt that ſpirit be, which can penetrate into this very cavity, which is likewiſe ſtopt up by the nervous filament that iſſues out of, and is contained in, it? Yet authors eſtabliſh ſuch notions; nay, they proceed ſo far, as to imagine, that the nutritious matter, to which ſome attribute the thickneſs of the white of an egg, paſſes through theſe very nerves: but this opinion is ſo idle and abſurd, that it does not deſerve a ſerious refutation. In the ſame light I conſider the imaginary fermentation between the ſpirits and blood, by which the muſcle is ſaid to be inflated; though the very method of this inflation is contrary to the known conſtruction of the muſcles.

Another thing that plainly contradicts the inflation and influx of the ſuppoſed ſpirit into the muſcles, is that we clearly ſee, tho' the muſcle be cut, and its moving fibres ſeparated from each other, all theſe parts move again, as it were naturally, as ſoon as the nerve which belongs to them is irritated: and this experiment, as well as others, may be made on the Frog, and ſeveral other water-animals, and it ſucceeds very particularly in the Duck.

From theſe experiments therefore, it may, I think, be fairly concluded, that a ſimple and natural motion or irritation of the nerves alone is neceſſary to produce muſcular motion, whether it has its origin in the brain, or in the marrow, or elſewhere.

Therefore, we likewiſe obſerve in many animals, that as ſoon as the beginning of the ſpinal marrow is moved in the brain, all the ſubjacent muſcles are ſuddenly contracted. And this happens in the ſame manner with reſpect to all thoſe branches of the nerves which ariſe out of the marrow, at leaſt whilſt they are handled; tho' only ſome of the muſcles, or perhaps that only, through which the irritated nerve is diſtributed, are put in motion. We muſt alſo take particular notice, that in this experiment, it is never obſerved, that the part of the nerve above the irritated region, contract alſo thoſe higher muſcles, that have their nerves from thence. We very clearly find alſo by experiments, that the motion produced in the muſcle by irritating the nerve, is always propagated out of the larger into the ſmaller branches, and goes afterwards continually deſcending. The nerves deſigned for the ſenſes are circumſtanced in a quite different manner; for in theſe, the ſenſitive motions, doubtleſs, tend upwards. In order to contract any muſcle, it is neceſſary that its nerve be irritated in the region above the muſcle, or at its inſertion into it; ſince that motion never tends upwards, but always downwards.

It may now be probably aſked, wherein I think the beginning of that natural irritation, ſtimulus or provocation of the motion, thus communicated to the muſcles through the nerves, conſiſts? Since I deny, that any viſible flowing and inflating ſpirits, are locally moved through the nerves; and, on the contrary, think that a certain inſtantaneous irritation is much more ſubtile, and capable of the effort, than the ſpirits ſuppoſed by ſome neceſſary to move the muſcles: and that, from thence, it follows, that this irritation ſhould not only have its origin elſewhere, but that a force is likewiſe wanting, by which that motion is transferred through the nerves into the muſcles. I confeſs theſe things are requiſite, ſince experience demonſtrates it even to the eye.

To give a proper anſwer to this queſtion, I think, the beginning or principle of that motion lies in the ſpinal marrow, and is alſo in all the nerves of the body; ſo that the marrow, and all the nerves, are conſtantly and perpetually irritated to give motion to every muſcle of the whole body. I would have it particularly obſerved, that I admit no eſſential difference between the natural and ſpontaneous contraction of the muſcles, and that performed by the will. I conſider this difference as merely accidental; but, becauſe we move all theſe muſcles, which we move voluntarily, in a contrary direction; that what is ſaid to be eſſential in the contraction of all muſcles, is a natural contraction. For this reaſon, voluntary motion ceaſes, or is changed in us, as well as in all other animals; when either the antagoniſt muſcles are wanting, or when one of a pair is more powerful than the other, as I have formerly demonſtrated in my treatiſe on Reſpiration. And indeed we cannot move muſcles at will, unleſs we have the power of determining the natural motion of the antagoniſts to the contrary ſide. But if all the motions of our muſcles are continual and natural, when the antagoniſts are wanting, as is the caſe with reſpect to many muſcular parts of our body, which we have not power to move at our pleaſure; only ſo far as thoſe muſcles are firſt dilated by their contents. Theſe perform the office of antagoniſt muſcles, and give us the power of moving them in a contrary direction at the command of our will:- but otherwiſe, all things acquieſce in the perpetual contraction.

In order further to explain the origin of this natural and perpetual contraction of the muſcles; I think indeed it ariſes from the continual impulſe of the arterial blood upon the marrow and nerves: for, by means of this blood, all thoſe parts ſeem to be continually moved, excited, and irritated to convey that motion pepetually and uniformly to the muſcles, and to prepare the latter for their perpetual contraction. For this reaſon, all the nerves without exception, have not fewer arteries in proportion, than the brain itſelf, and the ſpinal marrow have. I ſhould think indeed, that this matter might be eaſily aſcertained by experiments: for which purpoſe, I once thought of injecting a peculiar liquid through an artery into the marrow, by a ſmall ſiphon, and then to obſerve carefully, whether any motion was thereby excited in the muſcles. But I would again adviſe the reader, to conſider well that wonderful motion and power of the muſcle, when its nerve is in the leaſt diſturbed or ſtimulated.

It is now time to proceed further; and I ſhall, by a curious experiment, demonſtrate to the eye, that the muſcle is not at all ſwollen in its contraction, or becomes thicker by inflating it, and therefore occupies the larger ſpace; nay, on the contrary, that its ſwelling decreaſes: and therefore, in its contraction or action, fills leſs ſpace than when it reſts flaccid. I ſay reſts, becauſe I cannot obſerve that the muſcle in the living animal, ever abſolutely ceaſes from all motion. And therefore it ſhould be rather ſaid, that it is leſs ſtrongly moved at the time of its relaxation; or then only recollects its elaſtic ſtrength, that it may be able, the moment after, to make the ſtronger effort to contract itſelf. This may be ſeen very clearly in regard to the motion of the heart and auricle in the Frog; for the blood is there brought back from the circumference of the body, according to the laws of circulation, and being driven in to the auricle, it may be conſidered as the auricle's antagoniſt muſcle, which dilates it: but the auricle itſelf is the antagoniſt of the heart, ſince by means of the blood, which it protrudes into its cavity, it likewiſe dilates its ſubſtance, ſo that the wonderful, repeated, and continual pulſe of the heart, has its origin from this alone: that pulſe is therefore perfectly natural and neceſſary; for thoſe two muſcles, that is, the heart, and its auricle, are unequal in ſize and ſtrength, and therefore their motion is neceſſarily varied. If the auricle were as firm and as ſtrong as the heart, the motion of each would abſolutely ceaſe; for, wherever the power of the antagoniſt is equal, there is obſerved no motion of the muſcles, and all things are in both in equilibrio, until there ariſes another determination, which, cauſing one muſcle, to be contracted ſomewhat more ſtrongly than another, at length moves our limbs. Such a determination may proceed from various cauſes.

If, for example, a man's ſkin be very gently rubbed and irritated with a hair doubled ſeveral times; I often obſerved, that the motion of the antagoniſt muſcles of the arm and hand was immediately determined; ſo that the perſon inſtantaneouſly, as it were, unknown to him; has put his hand to the place where he felt the titillation, and then ſcratched the ſkin until he made it red, imagining that it was probably occaſioned by a Flea, or ſome other inſect. But when I ſtopt, his hand and arm reſted likewiſe, becauſe the natural contraction was then equal in all the muſcles. If the ſame experiment be made on ſleeping dogs or cats, it is likewiſe obſerved, that a determinate motion is produced in the muſcles which move their ſkin; and therefore it is pleaſant to ſee them ſuddenly draw it up, pricking up their hairs, and ſometimes ſkaking them in their ſleep. By this familiar inſtance, it is evident how our muſcles are in like manner voluntarily moved without any great attention of the will, by ſomething of this kind, which is proper to determine the natural motion of the antagoniſt to the contrary ſide.

Now, in order to make it certain from experiment, that the muſcle is not inflated in its contraction, but on the contrary poſſeſſes leſs ſpace, we are to take a very lively and ſound Frog, and diſſect it, uncover its heart, and carefully take away the pericardium from it. After this, we muſt chooſe one or two veins or arteries, which are large enough to be conveniently opened, and to admit a thin glaſs tube. By this tube, all the veins and arteries of the body, and conſequently the heart, may be very eaſily inflated; ſince, as I have before hinted, the lungs are in this animal no obſtacle.

When the heart is filled with air, it muſt be dexterouſly, together with its auricle, tied with a fine thread, and cut away from the body: then let a glaſs ſiphon be ready, one end of which muſt be a narrow and ſmall tube. Let the heart thus inflated, and its auricle, be put into the flat end of this tube, and let all be immediately put into that glaſs ſiphon; the long tube of which muſt, in the mean time, be ſtopt with a very ſmall drop of pure water, or, that it may be the better diſtinguiſhed, water coloured with blood.

Having duly obſerved theſe directions, it will manifeſtly appear, that at the time the heart, Tab. XLIX. Fig. VII. *a*, contracts itſelf within the little ſiphon, *b b*, the drop of water adhering near the extremity of the tube, *c*, deſcends in a very remarkable and ſurpriſing manner to the other end of the tube, *d*, where it ſprings from the ſiphon; and, on the contrary, it will likewiſe diſtinctly be ſeen, that the drop thus fallen down, *d*, will, on the heart's dilating itſelf again, riſe to its former ſituation, *c*.

This experiment furniſhes us with an evident proof, that when the muſcle of the heart contracts itſelf, not only all the fibres which ſerve to move it, are preſſed cloſer to each other, but that the heart itſelf alſo, occupies a ſmaller ſpace in its ſyſtole, than it did before in its diaſtole.

This alſo is the reaſon why the drop of water *c* moves downwards, *d*, as it cannot but follow the heart, when this contracts itſelf. But if at the very inſtant of the heart's contraction, any inflation, tumefaction, or dilatation, had been produced by the animal ſpirits on the inſide of this organ, the drops, inſtead of deſcending towards the belly of the ſiphon, *d*, would infallibly have riſen towards the extremity of the tube, *e*.

As the former never happens; and the latter, the very reverſe of it, is conſtantly the caſe, I may fairly and plainly conclude, that the muſcle of the heart requires leſs room by a great deal in its contracted, than in its dilated ſtate; and that hence the ſuppoſed ſpirits, by which it has been hitherto believed, that the heart, or its muſcle was puffed up at the time of its ſyſtole, has not the leaſt ſhare in producing that effect.

Moreover, if we open a living Frog, and carefully attend to the motion of its heart and the auricle, we ſhall find, that in this experiment, every thing proceeds exactly in the ſame manner as it did in the former. For, when the auricle contracts itſelf, it very ſenſibly grows ſmaller, and more compact,; but when the heart is again contracted, it undergoes the ſame alteration; and this obſervation is ſufficient to convince us, that there is no manner of difference between the two contractions of the heart, one of which takes place within the ſiphon, and the other naturally, except that the heart, out of the ſiphon, is inflated with blood, and with air in the ſiphon.

As to the other experiment made in the ſiphon, we muſt here particularly obſerve, what happens in the heart during its dilatation, and what change is ſeen afterwards during its contraction. When the heart dilates itſelf, we plainly perceive that the auricle begins firſt to contract, and while it does this, the air is forced from it into the heart; by which means it is conſiderably expanded, and appears in the ſiphon as if full of bubbles or bladders of air. It even becomes pale and tranſparent on this occaſion, and appears irregularly affected. This is owing to its moving fibres, and fleſhy columns, not being every where of the ſame thickneſs, ſo that ſome of the parts of the heart lying between theſe columns, are more diſtended by the impelled air than others. Thus at length is effected, the aſcent of the drop of water adhering to the glaſs tube.

When the moving fibres of the heart again contract themſelves, we obſerve that the heart draws itſelf in, and becomes ſmaller, and immediately after, we ſee the air forced from it, in its turn into the heart; upon which this laſt immediately becomes more red and opaque, and ſhrinks up ſo as to put on an unequal appearance: but as the heart at this time cannot return to the auricle, all the air it had thence received, its moving fibres approach towards each other with ſo violent an effort, that they likewiſe condenſe the air contained in them: and thus is the drop of water adhering to the tube of the glaſs ſiphon preſſed downwards, on account of the heart being then reduced to a leſs ſize.

This is likewiſe the caſe with the heart, which is naturally full of blood; for when this organ in its ſyſtole is diſtended by the blood, it draws away the circumambient air; but when it again contracts itſelf, and diſcharges its blood, it grows leſs, and yields to the air in proportion as it ſhrinks up, a thing which ought to be well attended

tended to, as it is very conſpicuous in a living animal. The blood itſelf undergoes ſome condenſation, when violently compreſſed by the contraction of the heart, and forcibly expelled out of it; but is alſo on the other hand ſomewhat rarified, when the heart is dilated by a new intromiſſion of blood, ſo that this natural action of the heart and blood correſponds exactly with that artificial one of the heart and air in the foregoing experiment.

It may be objected, that naturally in the live animal, the air by no means approaches the heart, and therefore cannot be repelled by it. But the contrary is plain in the caſe of Tadpoles, in which we ſee the external ſkin ſenſibly affected by the pulſations of the heart, and ſwell out and ſink in alternately, as that organ dilates or contracts itſelf, which is the ſame as if the air preſſed immediately againſt the heart itſelf. It cannot be denied, but that the ſame thing muſt happen in all animals that have lungs and gills, and a moveable breaſt; nay, it muſt, without doubt, take place in ſome motions of the muſcles.

If you cut a Frog's heart out of the body, and place it in the glaſs ſiphon, in the manner before deſcribed, without firſt blowing it up; you will plainly ſee the drop of water move in the ſame way it did before, though not ſo much as if the experiment were made with an inflated heart. In the mean time, the water alſo will ſink in like manner, when the heart contracts itſelf. Experience teaches us, that the deſcent of the drop of water in this experiment becomes ſometimes ſo inconſiderable, that it cannot be perceived, even by the help of the microſcope, which is owing to this, that the heart then continues partly contracted, and is not dilated by the auricle, which is now become inſufficient to produce that effect, as it neither propels any blood, or air, with which the heart could be diſtended. Hence, of courſe, the contraction of the heart muſt become proportionally weaker, and the motion of the water in proportion leſs diſcernible. But if you blow into the auricles at this time, that this auricle, by contracting itſelf, may force a quantity of air into the heart; the ſucceſs of the experiment will immediately become much more conſpicuous.

If, inſtead of the heart, we ſhould chuſe to make uſe of ſome other muſcle, we may proceed in the manner repreſented in the eighth figure, where the glaſs ſiphon, Tab. XLIX. Fig. VIII. *a*, contains within its hollow the muſcle, *b*, and the nerve hanging from the muſcle is faſtened, without being cut or bruiſed to a ſlender twiſted ſilver wire, *c c*, that runs at the other end, an eye made in a piece of braſs wire, ſoldered to the embolus or piſton of the ſiphon, *d*. Things being thus made ready, a drop of water, *e*, muſt be let into the ſlender tube of the ſiphon by a very fine funnel. Now, if after this, the ſilver wire be cautiouſly drawn with a lieſurely hand *f* through the ring or eye of the braſs wire, till the nerve is irritated by the compreſſion, it muſt by this means undergo, the muſcle will contract itſelf in the ſame manner with the inflated heart, whoſe alterations, upon a ſimilar occaſion, I have already deſcribed, even the drop of water will in ſome meaſure ſink, though afterwards it never riſes again. But this experiment is very difficultly ſenſible, and requires ſo many conditions to be exactly performed, that it muſt be tedious to make it; for which reaſon, I have bethought myſelf of another that may be more eaſily underſtood and performed.

You muſt have ready a little glaſs ſiphon, Tab. XLIX. Fig. IX. *a*, cut through with a diamond near the extremity of its ſlender tube, *b*; then paſs through the hole thus made, the nerve of the muſcle *c*: but as the air can eaſily make its way through this hole, while the nerve is irritated, till it contracts itſelf, ſo as to keep the water from ſinking; it is abſolutely neceſſary to ſtop that paſſage on the outſide, which may be eaſily done with a little iſing-glaſs and ſtarch. But I muſt own, that in this experiment, the ſinking of the drop is ſo inconſiderable, that it can ſcarce be perceived: for this reaſon, the heart is fitter for this experiment than any other muſcle, as it continues and keeps up for a conſiderably long time, and with ſufficient ſtrength, the motion it has once received.

There are ſufficient reaſons why this experiment ſhould ſucceed better when tried upon the heart, than upon the other muſcles; the principal ſeems to be this, that in the other muſcles, there is no antagoniſt to dilate them externally, nor any blood, which introduced into the blood-veſſels, can extend them, and diſpand the muſcle itſelf from withinſide; though all theſe conditions are abſolutely neceſſary to affect a perfect contraction in any muſcle.

The experiments which were ſome time ago publiſhed with a view of proving, that a quantity of blood is requiſite to contract the muſcles, do in reality no ſuch thing. Their principal weight lies in the conſtriction of the aorta, effected after D. Steno's method; but this is truly nothing to the purpoſe, and can only impoſe, at firſt ſight, even upon thoſe who examine matters of this kind with the leaſt circumſpection. For, by only conſidering with a ſmall degree of attention, that the vertebræ, many nerves, and even the ſpinal marrow, which are all faſtened by the ligament, directed by D. Steno, to be uſed on this occaſion, undergo thereby a violent compreſſion, it muſt plainly appear, that no concluſions can be fairly drawn from ſuch a trial. Much leſs can we infer any thing from the other experiment, in which the blood is expelled from the muſcles, to make room for water introduced into them by a ſiphon; ſince the moving fibres of the muſcle are conſiderably injured by this rough procedure; ſo that this coarſe experiment can only ſupport a weak argument with unthinking people, being calculated merely to confirm the experiment of D. Steno juſt now deſcribed. Stronger proofs may be reaſonably inſiſted upon, to demonſtrate a thing of ſuch importance, and the ligatures of the arteries of the thigh, particularly, in Frogs, muſt be allowed to be a great deal more to the purpoſe.

We ought, however, greatly to commend D. Steno's circumſpection, in not taking upon himſelf to determine the manner in which the motion of the muſcles is performed; neither was he bold enough to pronounce, for certain, that this motion proceeded from the influx or afflux of any new matter. But after I had, ſome years ago, made him acquainted with the experiments I had made on this occaſion, as already related, he made no difficulty of telling me plainly, that he was in no meaſure afraid of abſolutely denying the acceſſion of any new matter in the contraction of the muſcles; ſo that our opinions of this important operation perfectly coincide.

Even I myſelf, relying on the propriety and certainty of the experiments I have propoſed, can now, without any difficulty, maintain, that a muſcle, at the time of its contraction, undergoes no inflation or tumefaction, from the afflux or effervescence of the ſuppoſed animal ſpirits; but that, on the contrary, it in this ſtate becomes ſmaller, or collapſes; or, to expreſs my meaning more clearly, it takes up leſs room than it did before.

Nothing can be more evident than this alteration, when a heart filled with air inſtead of blood, or one quite emptied, is made uſe of; in the firſt of theſe experiments, there occur many other things worth our notice, which may all have place and force in the contraction of the muſcles: firſt the encloſed air in the heart is condenſed, and forced together; ſecondly, the circumambient air is dilated; thirdly, the fibres of the heart are moſt violently compreſſed and ſtrained in this action, and the little cavities within, or between them, are compreſſed; ſo that whatever has lain in theſe cavities muſt be diſcharged. And all theſe things appear chiefly at the time the heart relaxes, as it were for a moment in its contraction: fourthly, the internal air is afterwards again rarified in the heart: fifthly, the external air is on the contrary condenſed, and driven from its place: and ſixthly, the fibres of the heart are again extended or dilated.

If any one object, that the air in this caſe is out of the courſe of Nature in its place, I can readily anſwer, by aſſuring him, that I have found air in the hearts of human ſubjects, opened immediately after their death. But as this is not a common caſe, I am content, that blood may be ſubſtituted to the air which I ſuppoſed to be found in the heart: the blood contained in the cavity of the heart, is on that cavity's contracting, ſhaken, condenſed, and expelled; the ſame thing alſo happens to the blood which then flows through the coronary veins of the heart, and ſhaken, or violently driven out of them; upon which account alſo, the ſubſtance of the heart grows conſiderably paler at this particular time. Now, while the heart is thus contracted in its ſubſtance, the circumambient air is likewiſe rarified; and laſtly, the fibres which ſerve to move the heart violently, become powerfully contracted in the ſame manner with the inflated heart, as already mentioned. But the laſt appearances I took notice of on the ſame occaſion, and which were the reverſe of the firſt, deſerve to be here likewiſe conſidered, as they act in the enſuing dilatation of the heart, when in its natural ſituation, and when it is moved in its natural manner.

From all theſe particulars it evidently appears, that there occur in the contraction of the muſcles, a great many more things to exerciſe our reaſoning and induſtry, than authors have hitherto conſidered. And above all, we ought moſt carefully to obſerve, with what ſtrength the moving fibres of the muſcles draw themſelves up while the fibres are contracted. This power is ſo great, that I have ſeen them in ſome animals become three times ſmaller than in their natural ſtate of conſtant contraction. And on this account, all their contents, being all the blood and juices which had flowed into the blood-veſſels running through them, were moſt violently forced out by this powerful motion. Hence alſo it happens, that the muſcle of an animal, whoſe blood is red, is much paler in a contracted, than in an expanded ſtate. This D. Steno likewiſe has obſerved.

By this obſervation we are enabled alſo to account for the conſiderable heat cauſed in the body by the determinate and reiterated motion of the muſcles. For as the muſcles propel the blood from themſelves by their violent contractions, it is impoſſible the motion and circulation of the maſs of blood ſhould not be thereby conſiderably increaſed; a circumſtance which ſurgeons, who are informed of it merely by experience, have contrived in blood-letting, to take proper advantage of it; for at this time they give the patient a caſe of inſtruments, or ſomething of that kind, to employ his hands, that the muſcles being thus put in motion, the blood may more freely iſſue from the veins: the imagination alone is often powerful enough to have the ſame effect, as our muſcles are at that time variouſly influenced according to the lively or gloomy nature of the thoughts which then poſſeſs us, and proportionably contract and ſhut, or expand our hearts.

I ſaw myſelf, in the hoſpital of Leyden, a boy from whoſe feet the ſkin and fleſh had lately fallen off in a gangrene, who by the bare motion of his muſcles, without retaining his breath, could contrive to diſcharge at will a conſiderable quantity of blood from the wounded part. And I have likewiſe obſerved the ſame in the motion of many animals, whoſe blood, tho' they wanted lungs, flowed much more freely from them in motion, than when at reſt.

This caſe even extends ſo far, as to account for laſſitude or wearineſs itſelf, which is occaſioned by the muſcles being too much diſtended by blood, and conſequently rendered leſs fit for contraction, as I firſt obſerved, in ſhaping with my breath a piece of glaſs melted with a lamp heat; for the muſcles called Buccenatores in my face, came at laſt to be ſo violently diſtended

tended with blood by this operation, that entirely loſt the power of contracting them again, ſo as to be able to diſcharge the air at my mouth, in a manner requiſite for the buſineſs I was about.

It is very wonderful, how inſects in winter, when all their blood and humours are congealed, as it were, in their veſſels, loſe likewiſe all power over their muſcles; ſo that if their legs and other limbs be extended without doing them violence, they will remain in that poſture till the creature recovers the power of moving them, on the return of warm weather, or by being placed near a fire; for a very ſmall degree of warmth communicated to them in the beſt manner, is ſufficient to reſtore them to life and motion, to enable them to turn about, run, and even fly, till their blood and humours congeal again, which they do in a very ſhort time; and the little animal is thereby reduced to its former ſtate of inaction. I have likewiſe obſerved that famous vegetable called the Senſitive plant, is much leſs ſenſible in autumn, than in the ſummer ſeaſon.

It may be aſked how is the effect of the natural determinate irritation of the nerves, or even of that which is produced from without, and by art produced; ſince it is not poſſible to prove, or reaſonable to ſuppoſe, that any ſenſible matter is at that time conveyed, or locally carried into the muſcle; but, on the contrary, it muſt be allowed, that the muſcle diſcharges the matter it contained, ſo as to fill a leſs compaſs?

I muſt confeſs it a very difficult taſk to anſwer this queſtion, and perhaps impoſſible, till the true contraction of the muſcles ſhall be exactly known. For this reaſon I ſhall enter upon a method for attaining ſome certainty in this matter, like that purſued in acquiring juſt notions concerning the uſe of the eye; for the manner in which viſion is performed, was diſcovered without any true knowledge of the ſtructure of that curious organ, by which we enjoy that great bleſſing. Hence, were I permitted to make uſe of a coarſe ſimilitude, I might conceive it effected in the ſame manner with the alterations viſible on handling, or touching ever ſo gently the parts of the Herba Impatiens, called Touch me not, or podded Ars Smart, orthe Balſamita alteria of Fabius Columna; the parts of which plant being extended according to the courſe of two or three nervous or herbaceous fibres, in conſequence of any momentarry irritation, moſt ſuddenly contract, and the pods burſt.* And certainly, if theſe fibres, which cannot ſo expeditiouſly contract themſelves, before the ſeed of the plant to which they belong has arrived at its due maturity, did not curl up and fall off, but inſtead of thus periſhing, could be again dilated like leather, when forcibly bent, and excited by a new irritation to a new contraction, we ſhould have in them a moſt curious example of the action of the muſcles, the principal of which conſiſts in a contraction following a dilatation; ſo that it is the contraction of the muſcles, and not the dilatation of them, that we ought to conſider as their principal office, ſince even when the animal is dead, they will ſtill endeavour to contract themſelves. I have even ſeen a muſcle contract itſelf, when boiled in the ſame balſam in which I had preſerved it for ſeveral years.

Let people think what they pleaſe of the above-mentioned ſimilitude, or compariſon; at leaſt the experiment informing us that the muſcle contracts itſelf as ſoon as its nerve, is put in motion, reſts upon a moſt ſolid foundation: but as I demonſtrated at the ſame time, that a muſcle takes up leſs room in its contracted, than in its dilated, ſtate, it moſt evidently follows, that there does not flow into it at that time, as has been ſuppoſed, any expanding or rarefying matter, but that that ſubſtance muſt be inconceivably fine and delicate, which at that moment of time can produce in the muſcle ſo wonderful a motion; though we are not certain that this effect differs in any thing from that which the wind, a finger, a ſtick, or a briſtle, has in contracting the little fibres in the contractile pod of the Touch me not plant.

I therefore think, that, as I ſaid before, it may be from hence fairly inferred, that whenever the nerve is immediately irritated, the muſcle, to which it belongs, muſt be in a ſtate of perpetual contraction, or at leaſt in a ſtate of perpetual effort, and endeavour to contraction. This is a circumſtance, which I formerly obſerved in my treatiſe of Reſpiration, and ſhall hereafter more clearly explain, as I intend to publiſh a new method, in which we may in ſome meaſure conſider the conſtant motions of the muſcles.

But before I undertake this taſk, and thereby make an end of the preſent treatiſe, I muſt conſider in what ſtate or condition the muſcles were before they exerciſed any motion. This may be very eaſily ſeen in inſects, and even in the rudiments of the muſcles belonging to larger animals, whoſe muſcles at that time are generally compact, white, membranaceous, and ſeem compoſed at their very firſt appearance of a kind of glutinous humour. In inſects, it is very remarkable, that at the time of their changes, their muſcles become in a manner inviſible, and afterwards increaſe in ſize to a prodigious degree; nay, even their limbs diſappear, and grow in the ſame manner, but more particularly their legs, and the muſcles of thoſe parts, which ſwell and extend every way in a ſurpriſing manner, by means of the blood and humours driven into them, juſt as if they had been injected with additional liquors; ſo that in courſe of time, they are as it were unnaturally ſtretched, and bent in the manner of a bow. But this alteration obtains chiefly in inſects, whoſe muſcles alſo move much longer than thoſe of any other ſpecies of animals; and even retain their motion, in many ſpecies, after the head has been ſeparated from the body. We obſerve alſo, that as ſoon as inſects break from their old ſkins, their bodies grow larger every way, almoſt inſtantaneouſly; and the ſame thing happens, in proportion, to animals whoſe blood has an extraordinary degree of heat in it. Hence it is, that their muſcles endeavour the more violently to contract and draw themſelves together. In fine, we likewiſe very plainly ſee that the muſcles, when firſt they begin to exert their powers, grow much redder, on account of the blood penetrating at that time into their ſubſtance, and in ſome degree expanding it; and they become likewiſe much larger, by means of the blood-veſſels which run through them, and extend their moving fibres.

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* To the plants here mentioned by Swammerdan, may be added ſeveral others, in the ſeed-veſſels of which there is this elaſtick power, which he ſuppoſes in ſome degree analagous to the muſcular motion in animals: in the multitude of examples, the truth will be beſt diſcovered.

The Wood-ſorrel, wild Cucumber, and Lady-ſmock, among the common kinds; and in the Momerdica, Phylanthus, Euphorbiæ, Juſticiæ, Ruelliæ, Dictamnus, Ricinus, Tragica, Jatroplia, Cretan, Çlulia, and Realypha, among the more rare; and moſt of all in the Hura, or Sand Box-tree, which burſts with the report of a piſtol, and ſcatters its ſeparated parts throughout.

Theſe are the ſubjects in which the origin and cauſes of this motion in vegetable parts may be traced, and the ſubject is worthy a full diſquiſition.

From theſe particulars it evidently follows, that every contraction of a muſcle muſt be preceded by ſome degree of dilatation; and this dilation I ſuppoſe to be of three kinds. The firſt is performed in the natural and voluntary contractions of the muſcles, by the blood forced into, and thereby partly dilating them. The ſecond, which obtains, in natural contractions, I attribute to the contents, which by extending and dilating the moving fibres, and thereby drawing the blood more copiouſly to them, occaſions a relaxation of their contractile powers. The third kind of dilation is that which precedes the voluntary contractions, and ſeems to be produced by the determination of the antagoniſt muſcles; for theſe act upon the muſcles, oppoſed to them, in the ſame manner that the contents act upon muſcles, whoſe motions are natural.

Now what does that ſubtile matter, which conſtantly flows through the nerves into the muſcles, contribute to their contraction? Is it derived to the moving fibres, ſerving to open ſome of the blood-veſſels that ſurround the nerves lying within the muſcle? Or does it, by mixing with the blood, make it ſuddenly efferveſce and ferment, and ſo excite that motion, by which the muſcles may again ſhake off ſuch ſubtile matter, ſo as to cauſe an immediate contraction of the moving fibres? I muſt own myſelf unable to give a ſatisfactory anſwer to any of theſe queſtions, and therefore leave them, as a moſt fruitful matter of contemplation, to the diſcuſſion of others.

As to the other things which I have hitherto propoſed, I think I may thence moſt fairly conclude: Firſt, That all the muſcles are naturally contracted; that is, they are in a ſtate of contraction before they have performed any motion. Secondly, That their contraction is, in part, deſtroyed by the blood, and ſuch other humours as flow into them from their particular veſſels; and that this is, as it were, the firſt cauſe of the dilatation or expanſion of the muſcles, though they ſtill perſiſt in a ſtate of contraction in a leſſer degree. By this power alſo, the circumambient air is driven out of its place, and becomes condenſed, in the ſame proportion wherein the muſcles are expanded. Thirdly, The contents of the viſcera, cavities, and little tubes of the body, about which the moving fibres are diſpoſed, contribute greatly, as a ſecundary cauſe, which obtains in natural motions, to the complete diſtention or dilatation of the muſcles; whereas, in voluntary motions, ſuch complete diſtention and dilatation muſt be attributed chiefly to the contrary determination of the antagoniſt muſcles: for the moving fibres in theſe two ſpecies of muſcles, which are differently ſituated, are conſiderably expanded by theſe two cauſes, which likewiſe diſpoſe the blood-veſſels, belonging to the muſcles, to receive a far greater quantity of blood; ſo that the dilatation being once arrived at its higheſt pitch, the returning contraction may be the more powerful. Fourthly, The air, already repelled and condenſed, contributes greatly to produce this effect; for, by being immediately urged to dilate itſelf by the equilibrium of the atmoſphere, it, in its turn, acts with the greater violence upon the muſcles, to oblige them to return into their late ſtate of contraction; which is beſides ſo natural to them, that they would reaſſume it of themſelves, ſooner or later, without any ſuch compulſion. Fifthly, We muſt add to the cauſes already aſſigned, the perpetual and natural irritations which the nerves are conſtantly exciting in the moving fibres of the muſcles themſelves, and which are continually engaged in urging them to contraction. I would here be underſtood to mean thoſe ſtimuli, which are produced by the blood in its circulation, and in its paſſage through the arteries to the origin of the ſpinal marrow, and all the nerves; or elſe thoſe ſtimuli which are communicated to the beginning of the ſpinal marrow, and the nerves, by external objects, which make an impreſſion upon the blood. Hence therefore, in the ſixth place, the muſcles, as well the natural and moveable ones as thoſe ſubject to the dictates of the will, are neceſſarily diſpoſed, and in a manner conſtrained, to return to their original and natural ſtate of contraction. Hence, ſeventhly, I may reaſonably conclude, that in all the reciprocal contractions of the muſcles, their contents are again forcibly diſcharged, ſince the moving fibres, which were before extended, at this time come nearer again to each other, and become very compact, ſo as to recover the ſituation they were in, previous to their being dilated. For this reaſon alſo, they muſt then take up leſs room, though we may ſee ſome tumours ariſe at this time on the ſurface of the muſcles; theſe tumours being produced by the extraordinary compactneſs of the fibres, of which the muſcles are compoſed, and conſequently by the ſubſiding of the adjacent parts, rather than by any inflation of thoſe parts of which they themſelves conſiſt; as the authors, who have hitherto treated this ſubject, have falſly imagined. Seventhly, and laſtly, therefore, I from hence conclude, that all the actions of the muſcles conſiſt in contraction, or in a return to that form and diſpoſition they had before they were dilated; ſo that the muſcles, as often as they are again dilated, or determined a contrary way, by the cauſe already aſſigned, or by means of their contents, or by the action of the antagoniſt muſcles, conſtantly return afterwards to their former ſtate of contraction, whether the motions they are to give be natural or voluntary.

Though this be uſually the caſe, and principally with regard to the natural motions of the muſcles, it nevertheleſs is obſerved to take place in their voluntary motions alſo; though, to effect theſe laſt, the conſent of the will is likewiſe neceſſary. For we find, that, in all the voluntary motions of the muſcles, there is likewiſe abſolutely required ſome internal or external cauſe, by means of which a contraction of the antagoniſt muſcles may be determined another way.

Therefore, ſince all the muſcles are in a perpetual ſtate of contraction, it is eaſy to conceive, that the leaſt degree of determination, whatever cauſe may ſerve to produce it, is ſufficient to diſpoſe them to move the body, make it advance, remove it from place to place, and actuate it in a thouſand other different ways.

Nor is it in natural motions alone, that things are obſerved to proceed in this manner, as plainly appears by the contraction of the pupil of the eye, which inſtantaneouſly expands and dilates itſelf, by means of its muſcles, as the eye is more or leſs irritated by the particles of light. The ſame may be obſerved of the moving fibres of the inteſtines, which conſtantly alſo contract and expand themſelves, in proportion to their contents; ſo that their motion perfectly reſembles that of the ſea, whoſe waves follow and mutually preſs upon one another.

We often obſerve, that a natural contraction takes place in thoſe muſcles, which are ſaid to move as the will directs; as is manifeſt in our walking, ſtanding, and making uſe of our hands: for we certainly move our limbs almoſt every moment, without reflecting in the leaſt upon what we do. Thus, with regard to external objects, we often ſalute a perſon we meet, merely becauſe another in our company takes off his hat, or becauſe we are affected by ſuch external object, though we do not know who the perſon is we have ſaluted, nor ſo much as think of our ſaluting him. For this reaſon therefore it is plain, that as our memory is local, and is aſſiſted by the image of one thing in paſſing to that of another, and ſo on without end, the contractions of our muſcles are in like manner natural; and the muſcles themſelves are urged by one cauſe of motion to another, and from this to a third, and ſo on without any interruption.

It is for a ſimilar reaſon, that, when we find ourſelves too near the fire, we retire to a greater diſtance from it, and put our limbs, by means of various motions, into their former poſture, without attending in the leaſt to what we do; but merely in conſequence of the impreſſion made upon us by the irritating object. From hence it appears, that we can never be truely ſaid to move voluntarily, unleſs when the will itſelf is put in motion by the object, and then by its own motion produces a third; for whenever the light happens to be too ſtrong, we ſhut our eyes, turn our head aſide, and give ourſelves many other motions, as we are variouſly excited to them by the objects that preſent themſelves.

All theſe facts abundantly prove, that thoſe very muſcles, by whoſe aſſiſtance we perform our voluntary motions, are notwithſtanding always themſelves moved in a natural manner, not only becauſe an internal or external principle, cauſe, or object is alone requiſite to determine them; but likewiſe becauſe a voluntary motion is never produced, unleſs ſuch a determining principle, whatever that may be, precedes it, though it ſhould be but a thought merely caſual, let alone one previouſly excited. Cannot a ſimple dream, or ſome abſolute phantom, preſenting itſelf before us in the night, ſo affect us? Even in this caſe, we immediately ſtart, tremble, and perhaps get out of bed, ſhriek, and call for aſſiſtance. And all this we do merely becauſe we then juſt determine another way our muſcles, already prepared for action. We may obſerve the ſame things alſo in our ſpontaneous or natural motions, though ſuch motions can be but very ſeldom determined by us, and that alſo under certain conditions only. For our will, as I took notice in the beginning, has very little power in determining ſuch of the muſcles as have no antagoniſts; and indeed, if nature had not beſtowed upon us ſuch antagoniſt muſcles, we ſhould have been little better than vegetables, which cannot ſtir from the place wherein they have taken root.

It is evident, from the foregoing obſervations, that a great number of things concur in the contraction of the muſcles; and that we ſhould be thoroughly acquainted with that wonderful machine our body, and the elements with which we are ſurrounded, to deſcribe exactly one ſingle muſcle, and explain its action, in a ſatisfactory manner. On this occaſion, it would be neceſſary for us to conſider the atmoſphere, the nature of our food, the blood, the brain, marrow, and nerves, that moſt ſubtile matter which inſtantaneouſly flows to the moving fibres, and many other things, before we could expect to attain a ſight of the perfect and certain truth. For my part, I own that I have endeavoured to offer ſomething on this important ſubject worth the publick's acceptance; but yet I am ſenſible, that all this time I have been, as it were, repreſenting with a coal the ſun's meridian rays: ſo that this my little eſſay can pretend to no merit, on any other account, but that of its conformity to Nature, which I hope I ſhall, in time, be allowed not to have miſrepreſented. And that time will be, when happier geniuſes ſhall have made all theſe things clear and evident; for this may certainly be attained by laying aſide all little thoughts of our own glory, in inveſtigating the works of Nature, and thinking of His only, without whoſe aſſiſtance we could not even know any thing of them. At that happy period, the deſire of writing for the ſake of being talked of, will no longer prevail: we ſhall not then be anticipating our own praiſes, ſince all our intentions being directed to the honour of the Creator, we ſhall of courſe reſiſt the corrupt motions of our hearts, apt to be delighted with flattery, and fond of obtaining the title of learned and ingenious men: all which I only conſider as vanity of vanities, ſince truth is the only thing upon which we ought to depend, as on a firm foundation, and for which we ought to value ourſelves. Who is it amongſt us, that ſhall diſcover the truth, conſidering our blindneſs in judging even of the viſible objects that ſurround us? Hence therefore, to conclude this eſſay, I ſhall obſerve, that every true and valuable diſcovery is the gift of the Divine Grace, which God diſtributes as he pleaſes, and makes manifeſt at his own time. My obſervations, concerning the nerves, may be found in my hiſtory of the Rhinoceros Beetle.

The End of the Natural Hiſtory of Frogs.

A compariſon of the changes in the Clove-Julyflower, with thoſe in inſects during their Nymph-ſtate.

TAB. XLVI.

I Exhibit in the figure of this Table,

N°. I. The garden Caryophyllus, or Clove-Julyflower, under its firſt coat or tunick, within which it goes by the name of the ſeed of the plant.

II. The ſaid coat or tunick fallen off from the latent rudiments.

III. The little new germen, or firſt ſhoot of the plant.

IV. The ſaid germen opened into a few leaves.

V. The ſame germen or bud, when its folliculus or flower-cup is called a gemma, or bud; in which condition I conſider it as a Nymph.

VI. The Caryophyllus or Clove-Julyflower itſelf, after it has burſt open its gemma or bud, and is become ready to ſhew its ſeeds.

Having ſhewn in general, in the firſt part of this work, the ſimilitude there is between the changes of vegetables and thoſe of inſects, I ſhall now, to make it the plainer, give a particular inſtance of it in the Caryophyllus or Clove; adding figures, to make every thing the more intelligible *.

Tab. XLVI. Fig. I. Firſt then I give a figure of this plant's ſeed, as it appears to the naked eye; and then, at the letter A, I repreſent it as it appears through the microſcope. Near the middle of it there appears a white protuberance; by which, while it remains in its cell, it receives life, nouriſhment, and increaſe, in the ſame manner with the eggs of inſects in the ovary; ſo that we may conſider this firſt principle, which is likewiſe found in other ſeeds, as the cicatrix of the navel-ſtring, after it has been cut and tied up. There appear alſo, on the ſurface of the ſeed of the Clove-Julyflower, ſome very pretty little jagged unevenneſſes, interſperſed with black ſpots; by means of which it looks not unlike that rugged ſkin called chagreen, and may indeed be very aptly compared to that kind of ſkin.

Fig. II. Secondly, I exhibit the coat, ſkin, ſhell, peel, rind, or tunick, which the Clove-ſeed throws off, in order to appear under the ſhape of a germen, or firſt ſhoot, III, juſt as inſects caſt their ſkins at the time of their changes.

After having repreſented the external appearance of the Clove-Julyflower-ſeed, N°. I. and A, I give the form of the ſkin it has caſt off under N°. II. At the letter B, I give the true appearance of the ſeed contained within that ſkin or coat, drawn after nature; and at the letter C, as it appeared through the microſcope, that my readers may be able to form juſter notions of it. There are two things in this ſeed which deſerve particular regard; namely, its prominent apiculus, or point, and that bivalve diviſion or parting which is to be ſeen in the reſt of its body. On the ſeed's being committed to the earth, we obſerve that the point or cone bends downwards, and divides into roots at its extremity, N°. III. whilſt the reſt of the body of the ſeed, opening more and more, at laſt throws off its external coat, N°. II. and conſtitutes the two firſt leaves of the future plant.

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* In the courſe of vegetable nature, if the ſyſtem of vegetable generation, juſt publiſhed by Dr. Hill, be found to anſwer equally in all other plants as in the inſtance there propoſed, the origin of this part of Nature's products is very ſimple. There remains nothing of that incomprehenſible doctrine of invigorating atoms, or a ſeminal air; but the whole operation is a continued growth. The fibres of the root are compoſed of five ſubſtances, laid over one another, and theſe terminate in the ſeveral parts belonging to the flower. The fleſhy ſubſtance of the ſtalk terminates in the antheræ, and each termination of it is in a minute plant, which is lodged in a grain of farina, and defended by a watry ſubſtance: it is with this carried down the ſtyle into the ſeed-veſſels, and lodged in the ſeeds. Theſe cover it with new membranes; and when put into the ground, it caſts off theſe membranes, and acquires its growth, juſt as this author obſerves of the Clove; confirming all his obſervations.

Fig. III. As repreſented after nature, under the third number. I here exactly exhibit the two firſt leaves of this plant, with its root, and the fibres belonging to that part, and all the tender little rudiments of the infant Clove-Julyflower, which at this period exactly reſembles an inſect; that has juſt crept out of its firſt coat or ſkin.

Fig. IV. Fourthly, I exhibit the germen of the Caryophyllus, or Clove-Julyflower, ſomewhat more grown, and adorned all round with excreſcent leaves, which may very well be compared with the little bundles of hair ſpringing from the ſkins of Caterpillars.

Fig. V. I ſhew in what manner the germen, or firſt ſhoot, has at laſt grown to a gemma or bud, calyx or cup, which contains the latent Clove-flower, neatly folded up; in the ſame manner that the Nymyh or Chryſalis contains the future flying inſect. But there is this difference, that the parts of the Clove are uniformly ſurrounded with one continued coat or ſkin, like the embryo Chicken in the ſhell of its egg; whereas all the limbs of Nymphs or Chryſallides are wrapped up each in its own pecular covering, without being ever found under one common coat, unleſs it be in ſuch inſects as never throw off their laſt ſkin; as is the caſe in the fourth order.

Fig. VI. Laſtly, I give a drawing of the Clove, at the time when it is in flower: when, after having burſt its calyx, gemma, or bud, in the ſame manner that the new Butterfly breaks from its Nymph or Chryſalis, and acquired its full ſize, and age proper for ſhedding its ſeed; it ſeems to wait, in its gay attire, for the coming of its mate, juſt as inſects do for an intercourſe with theirs. But as the Great Architect has not allowed plants a power of motion, and has ordered that they ſhould propagate the ſpecies without copulation, this little flower by degrees breathes forth its life, by a continual evaporation of the moſt fragrant odours, reſembling the breathing forth of ſo many amorous wiſhes; and finds only in its death the means of making itſelf immortal in its offſpring.

There are likewiſe inſects, as I have elſewhere obſerved, which, though diſtinguiſhed into males and females, propagate their ſpecies without any venereal intercourſe. Of this kind is the Ephemerus. Even animals that have blood, as fiſhes, for example, are found alſo to perpetuate themſelves in the ſame manner.

If, therefore, we attentively conſider the order in which the parts of inſects, larger animals, and vegetables increaſe, and alter from one form to another, and the other particulars belonging to ſuch increaſe and changes, we ſhall evidently ſee, that all God's works are really founded upon the ſame rules, and agree together with an inconceivable regularity. But who is it, that, after ſeriouſly reflecting upon ſuch an agreement, dare maintain, that the meaneſt being under the heavens can owe to mere chance its eſſence, exiſtence, perſervation, and rank in the creation?

As the generation, breeding, increaſe, and changes obſervable in the Louſe, the Dragon-fly, the Ant, Butterfly, and common Fly, how often ſoever repeated, are obſerved to obey conſtantly the ſame laws, remain within the ſame limits, and proceed in one uniform and certain manner; what reaſon can there be to ſuppoſe, that the other parts of the creation ſhould be governed with leſs wiſdom, power, and goodneſs? What grounds for the leaſt diffidence in the Great Lord and Maſter of ſuch an univerſe? What powerful motives rather have we not, to acquieſce humbly in his counſels, adore his omnipotent hand, and praiſe his works, whoſe exquiſiteneſs infinitely ſurpaſſes the ſtrongeſt efforts of the moſt ſubtile and daring imaginations?

The Concluſion.

Concluding this work, I cannot but obſerve that the manner in which the inſects I have treated of, and all others, eſcape the injuries of the cold and rainy ſeaſons, is of too much importance, and too ſurpriſing in itſelf, not to deſerve ſome ſhare of our attention. Experience has taught me, that they do this in four different ways.

Firſt, I have obſerved that the inſects themſelves, which have acquired their full growth and perfection, outlive the rigours of winter; at which ſeaſon they ſo entirely loſe all power of motion, that when taken from the little places of retreat they had choſen for themſelves, during the autumnal months, as beſt agreeing with their ſeveral natures and diſpoſitions, they cannot by any means reinſtate themſelves. But if you cheriſh them gently with a warm hand, or hold them at a proper diſtance to the fire, they not only ſoon recover the power of moving themſelves, but likewiſe the uſe of their wings, with which they fly about as before, till the coldneſs of the circumambient air has again numbed them, or they have found other convenient winter-quarters. That all inſects do not equally loſe this power of moving themſelves, is plain, among many others, in the caſe of Bees; for theſe not only open and ſhut the doors of their hives in the winter ſeaſon, but tenderly and diligently nurſe and rear their young offspring in the very depth of it. Hence it is, that not only young Bees may be found in the hives at the firſt dawn of ſpring; but that even it is a common ſaying amongſt thoſe that delight in this uſeful inſect, that young Bees and Swallows make their appearance at the ſame time.

Swallows feed upon Bees and other inſects, which they ſeize in their moſt rapid flights. For this reaſon, in rainy weather, when no inſects are to be found in the air, theſe birds, in order to take them, fly near the ground; a circumſtance which has given a handle for that very abſurd notion of ſome people, that Swallows can foreſee an impending ſtorm; whereas, as I have been juſt ſaying, they ſkim the earth in heavy, cloudy, rainy, or ſtormy weather, merely to come at the inſects, upon which they prey, and which, at theſe times, always betake themſelves to reſt. For the ſame reaſon I believe Swallows conſtantly follow the courſe of the Sun; and when winter comes upon us, retire to the other climates which enjoy at that time a pleaſant ſpring, a fruitful ſummer, or a temperate autumn, and are thereſore qualified to ſupply them with a ſufficiency of food.

I have obſerved, that ſome inſects can only endure the winter in the worm-ſtate. Theſe are found not only above and under ground, in the hollows of trees, between the leaves of plants, in the hearts of fruits, and in vegetable excreſcences, but even in the water, and are often encloſed in ice. But then it is obſervable of theſe inſects, that moſt of them are much ſtronger at this period, than ever they are afterwards, when they have gone through their changes, and are become capable of propagating of their ſpecies. Thus we find that the Water-worm, which changes to an Ephemerus, is ſo tenacious of life, that it can live many days after being run through with a pin; whereas in the Fly-ſtate it lives even without receiving the leaſt injury, but four hours at longeſt. However, we likewiſe know by experience, that theſe creatures, tho' vigorous and robuſt, periſh very ſuddenly, if they do not happen to find quarters adapted to their nature. Of this the Worms found in Hazelnuts and filberts, are a ſtriking inſtance; for unleſs you place them in moiſt ſand, where they dig themſelves holes to ſerve them for winter-quarters, not only they die very ſoon, but even in the ſpace of one ſingle night, will harden, and dry to ſuch a degree, that they will in a manner fall to duſt between the fingers. I have obſerved alſo, that this is the caſe with the Worms bred in the tubercles of Mallow-leaves, tho' they never make holes for themſelves in the earth, in which they may paſs the winter, but defend themſelves againſt its rigours, by ſpinning a commodious covering for their bodies.

Thirdly, I find that other inſects paſs the winter in the Nymph-ſtate, in which they may be found as well on the ſurface of the earth, as buried under ground; and even in the water, where they will live for ſome months without any food; for at this time, they want ſtrength to take any, as well thro' the weakneſs of their limbs, as on account of the great quantity of ſuperfluous moiſture with which their bodies are charged. I have likewiſe remarked, as I already mentioned, that the greateſt part of theſe inſects, which outlive the winter in a perfect ſtate, require no food from one end of that ſeaſon to the other; for at that time their juices move very ſlowly, and are in a manner condenſed by the coldneſs of the circum ambient air; both which are ſufficient to account for ſo long a faſt.

Hence it is alſo, that theſe little creatures, when cheriſhed with the leaſt warmth, recover their former ſenſes and motion; whereas, before, they were ſo entirely motionleſs, as even not to void any excrements. And this circumſtance affords us another proof of their not taking any food at that time; for where there is no loſs, there can be no neceſſity for any nouriſhment to repair the waſte.

Fourthly, and laſtly, I have found inſects to ſurvive the winter in their eggs; in which, as I have heretofore obſerved, they often wear the form of Nymphs.

But I ſhall hereafter explain the advantages that accrue from this condition of Inſects in the Nymph, and other ſtates, when I come to deſcribe after what manner they bury their eggs in ſpring, on the approach of warm weather, in the tender germina or buds of plants, and in the leaves of trees; a thing which I mightily long for the ſatisfaction of ſeeing with my own eyes. Perhaps I may at laſt find the means of ſatisfying my curioſity. And, as no deſcriptions or drawings can impart full and juſt notions of the form and external appearance of theſe little creatures, I have formed a reſolution of collecting ſome hundreds of them, in order to preſerve them in balſam, after having ſufficiently dried them.

I could prove by the teſtimonies of people of all ranks, that I have in my muſæum ſpecimens of all the inſects I have ſpoken of in the foregoing treatiſe, to the number of more than twelve hundred, with their Nymphs, Chryſalides, and Vermiform-nymphs. But here, in order to do myſelf juſtice, I appeal to that moſt curious and learned gentleman the Abbé Boucaud, who, after he had been firſt to ſee me, in company with the celebrated Olaus Borrichius, Profeſſor of Phyſick in the Univerſity of Copenhagen, thought it not beneath him to return often to my houſe to examine the great number of natural curioſities I have there treaſured up.

I might likewiſe appeal to the moſt noble and accurate Paul Falconier, who ſome time ago did me the honour of a viſit, and was pleaſed to approve my occupations and ſtudies. But I would not have the readers imagine, that I have minutely examined every ſingle inſect of my collection; I have only reduced a great many of them to my four orders, as may appear to any one, that will be at the pains of conſidering what I have ſaid of theſe orders. And this caution I gave in the ſame place, for fear of deceiving others, and perhaps myſelf, with expectation of more being done in this branch of natural hiſtory than there really is. Though, let us do as much as we can, I believe it ſo far from poſſible to know every ſpecies of inſects, and the changes of each, that I believe the labour of ages would not be ſufficient to diſcover all the kinds of them. In the mean time, I challenge any one to produce a ſingle inſect, that may not be referred to one of the four orders of mutations which I have propoſed; for to me, if I may here truſt my reaſon, the thing appears impoſſible. I leave it to time to diſcover the truth of this aſſertion; and do not deſire any credit to be given to my relations, unleſs the things I ſpeak are found to agree exactly with the originals, as I have deſcribed them after nature with all the exactneſs and perſpicuity I was maſter of.

Having thus produced every thing, which in my opinion could be ſaid in general, or in particular, concerning inſects, I had reſolved to add another diſſertation on their eggs, worms, and Nymphs: but I muſt defer this to ſome other opportunity. I had even flattered myſelf with the hopes of being able to preſent the public with a ſeparate account of the little inſects found in the bodies of others of a larger ſize; but as yet I want ſufficient experiments for that purpoſe, though I am firmly perſuaded that nothing is to be attributed to chance in the generation of them.

I ſhall now ſay no more on this ſubject, as it is moſt evident that all God's works are governed by the ſame rules; and as the true and primitive origins of them are infinitely beyond the reach of our comprehenſion, ſo that we cannot be ſaid to know more than the bare outlines of that infinite Being's image, to whom they owe their exiſtence; ſo I may hence, for certain, conclude, that all the knowledge and wiſdom of philoſophers, conſiſts merely in an accurate perception of theſe elegant appearances or effects, which are produced by firſt cauſes, and are often themſelves, in their turn, the cauſes of other effects. For this reaſon, we ſhould ſtrenuouſly endeavour to make ourſelves well acquainted with theſe appearances, and then draw from them firm rules and principles; otherwiſe, as I have hinted in my preface, we may eaſily loſe our way, and ſtray into the paths of error, as diſputing on nature, which is quite inexhauſtible, without ſufficient experiments, which, on ſuch an occaſion, are as neceſſary to find us a path, conſidering with what darkneſs of ignorance we are ſurrounded, as a ſtaff is to the blind. It often happens, through our own fault, that thoſe things, of which we might acquire competent notions with very little trouble, become not only dark, but quite incomprehenſible to us, ſo as to encreaſe our blindneſs, by the erroneous inferences we draw from them, rather than add to our knowledge. Of this our great weakneſs, Goedaert alone is a ſufficient example; for that author, by falſely imagining to himſelf, for want of proper experiments, that Caterpillars, degenerated into crippled and imperfect inſects, as often as they performed their mutations, without being properly grown and fed for that purpoſe, not only in conſequence of this falſe poſition, involved all his other experiments in the moſt perfect darkneſs, but contracted himſelf ſuch a blindneſs, that he could not perceive one of the moſt excellent principles of natural hiſtory, though it lay directly under his eyes. I omit naming many other naturaliſts, who, too lazy, or too proud, to make experiments, and guided only by their weak reaſon, or weaker imagination, have argued on the mutations of inſects, with juſt as much propriety, as a blind man may be ſuppoſed to ſpeak of colours; inſomuch that I ſhould be aſhamed to put my readers in mind of their empty and childiſh reaſonings. Nor is there the leaſt ſhadow of excuſe, for the unwarrantable boldneſs of ſuch perſons, who were not aſhamed to ſpeak without any heſitation or doubt of things, whoſe cauſes and principles they were utterly unacquainted with. But, to ſpeak my mind with freedom and candour: if we are to regard as idle and vain, all thoſe reaſonings of ours, which cannot be primarily demonſtrated by experiments, and do not ultimately terminate in them, no reaſonings can be ſo ſtrong and certain, as thoſe which are drawn from the very obſervations and experiments, in which they may likewiſe be found to terminate. All ſuch arguments, therefore, as want this firm and immoveable baſis of experiments, are to be greatly ſuſpected of error, whatever ſyllogiſms and enumerations people may think proper to build them upon; and when they do not exactly agree with experiments, they deſerve to be rejected. Of this opinion was likewiſe the illuſtrious Des Cartes, who, in his eſſay upon method, has the following words. "For I was always of opinion, "that more truth is to be found in thoſe reaſonings, which men make uſe of in the common affairs of life, whoſe bad ſucceſs may "prove a kind of puniſhment for their reaſoning ill, than in thoſe which ſome idle doctor, "cooped up in his ſtudy, has invented concerning this *entia rationis*, and ſuch other empty "queſtions, that conduce nothing to the eaſe and "happineſs of life, and from which he expects "no other advantage, unleſs that of reaping ſo "much the greater harveſt of empty glory from "his arguments; as they contain leſs of truth "and common ſenſe, on account of the extraordinary ſtrength of genius, and application "requiſite to give an impoſing air to ſuch abſurdities."

If we duly conſider the words of this able philoſopher, and the great weight and importance of experiments, I believe we ſhall find it not unjuſt to dignify with the name of reaſon that faculty of our minds, by the aſſiſtance of which, we form clear and diſtinct notions of things, whilſt we make proper uſe of our ſenſes in ſufficient experiments, ſo as to be able afterwards to effect exact copies of the originals we have thus endeavoured to be thoroughly acquainted with. For this reaſon it is, that our idea of any thing is ſaid to be more or leſs clear and diſtinct, according as we can produce another thing more or leſs like it; and are therefore ſaid to have more or leſs the power of it. This being granted, it ſhould follow, that we have no clear, diſtinct, or perfect knowledge of any things, except of ſuch as we can truly and effectually produce, according to the notions we have of them: ſo that ſolid and perfect knowledge muſt be allowed to be a very uncommon thing in man, and to be confined within very narrow bounds. This is an imperfection we ſhould readily confeſs, if a principle of vain glory, cheriſhed by that very ignorance, did not prevent us. To give an inſtance of theſe things, which are in ſome ſort underſtood by us, I believe phyſicians, if they had clear and diſtinct ideas of the ſtructure of our bodies, and of the motions of the blood, and other juices belonging to them, would be able to mend radically any unnatural diſpoſition in theſe parts, as they could then prove the validity of ſuch clear and diſtinct ideas, by reducing them to the teſt of experiments, which is allowed in every country to deſerve credit, more than reaſon itſelf. But as hitherto they are very unhappy in their attempts to cure our diſorders, and are always perplexed by croſs events, from the weakneſs of their reaſonings; we cannot but allow from this, and all, that the great Deſcartes has beſtowed no commendations on experiments which they do not highly deſerve.

It is plain, from what has been ſaid, that ſomething may exiſt in the underſtanding, which never before had been taken notice of by the ſenſes, tho' we cannot comprehend them clearly and diſtinctly, unleſs they terminate in the ſenſes, or at leaſt may effectually terminate in them. Beſides, our underſtanding becomes at length ſo diſcerning, as through a frequent and attentive obſervation of experiments and ſenſible effects; ſometimes we are enabled to judge truly and ſolidly, without any previous experiment of things, which have never fallen under the cognizance of our ſenſes. To this purpoſe, is what Ariſtotle ſays in the tenth chapter of his third book concerning the generation of inſects. " We " muſt truſt our reaſon, if what it demonſtrates " be found to agree with the informations of " our ſenſes."

All things therefore duly conſidered, it does not ſeem unreaſonable to determine, that if we had clear and diſtinct ideas of the ſtructure of the human body, the motions of its juices, and every thing elſe relating to that wonderful fabrick; not only we ſhould be able, by making a proper uſe of ſuch ideas, to mend it when impaired, but might even ſo far go beyond the bounds of nature, as to reſtore its health and vigour, when entirely loſt and decayed. For our induſtry ſucceeds the better, in producing things the more clearly and diſtinctly it comprehends them; whilſt ignorance, on the other hand, is attended with a proportionable degree of weakneſs.

But as it is not always in our power to make accurate experiments or obſervations, ſo neither are ſuch experiments always ſufficient to give us clear and diſtinct notions of the things themſelves. Such, for example, as on account of their extreme minuteneſs or remoteneſs, elude the ſharpneſs of our ſight. Let therefore no one be childiſh enough to perſuade himſelf, that we can, by the bare efforts of our reaſon, ever thoroughly underſtand the genuine cauſes of ſuch things; not to ſay the true effects produced by them.

For the higheſt degree of wiſdom we are capable of attaining, does not conſiſt, as I obſerved before, in the knowledge of cauſes, but only in the clear and diſtinct comprehenſion of the true appearances or effects, by which ſuch cauſes diſcover themſelves to our ſenſes; but we afterwards make uſe of theſe effects, as ſo many ſteps by which we may climb to the firſt cauſes, and by the juſt notions we thus acquire, we are enabled to produce an infinite number of things requiſite to make life eaſy and happy. Nay, even this knowledge reaches no higher than the perception of theſe effects, as they are made known to us by a circumſpect uſe of our ſenſes. And therefore, all our reaſonings that are drawn from experiments already made in one caſe, and then applied to another, in which we have not as yet made any, are to be held as dubious and ſuſpectible till they end in, and are confirmed by immediate experiment.

For this reaſon I am greatly pleaſed with the illuſtrious Harvey, when in the preface to his treatiſe on the generation of animals, he ſpeaks of the methods of finding truth, in the following words: " The preſent method " therefore, of inveſtigating truth, is alto- " gether erroneous and childiſh, whilſt the " generality are taken up in inquiring not what " things are, but what others ſay of them, and " then drawing an univerſal concluſion from " ſingular premiſes, to which they often af- " terwards add analogical reaſonings, and al- " moſt always palm upon us for true, things " that are ſeldom more than at the utmoſt " probable. Hence it is, that many ſophiſts, " after ranſacking the inventions of others, " preſent them to us as their own, though " they have done no more than change the " original author's order and words, and made, " perhaps, ſome few inconſiderable additions; " by theſe means they render philoſophy, " which ought to be certain and perſpicuous, " dark, intricate, and confuſed. For thoſe, " who whilſt they read an author's words, do " not abſtract the images of things, compre- " hended in their words from their proper " ſenſes, inſtead of furniſhing their minds " with true ideas, fill them with falſe idols " and empty fancies, which they work up in " their imagination, into ſhadows and chime- " ras; ſo that all their fine theories or con- " templations which they dignify with the " name of knowledge or ſcience, ought ra- " ther to be conſidered as the dreams of men " awake, or the ravings of lunaticks." And a little before, he ſays, " For the images of " things that come under the cognizance of " our ſenſes, remain when the things them- " ſelves have diſappeared; and theſe images " conſtitute memory, which, by taking in a " great number of objects, forms in its turn, " what we call experience; and from expe- " rience we derive univerſal reaſon, definitions, " and maxims, or common axioms, which " are the certain principles of knowledge." He again ſpeaks to the ſame purpoſe in his forty-fourth exercitation, and in the following terms. " It is therefore, no ſuch wonder, " that ſo many errors ſhould have deſcended “even to our times from the remoteſt antiquity, with the unanimous conſent and approbation of mankind; or that men of great abilities in ſome reſpects, ſhould have committed miſtakes, as they thought it ſufficient to be wiſe with the wiſdom of others, or learned with their learning, and to fill their memory with the opinions of learned men. But thoſe who philoſophize in this manner by traduction, if I may thus expreſs myſelf, are not a whit wiſer than the inanimate books through which they come at their ill-digeſted notions.”

Thus alſo, the great Deſcartes ſpent his whole life in endeavouring to make philoſophy a practical ſcience, inſtead of a merely theoretical one, as it had been to his days, that thereby he might make it ſubſervient to the moſt important purpoſes of life and health. But as he conſidered he might not perhaps live long enough, or be able to make enough of experiments to accompliſh ſo noble a deſign, he warmly exhorts men of ſuperior abilities to ſuch a taſk, and to loſe no opportunity of making experiments, and reducing every thing to that ſure and infallible teſt. To this purpoſe he ſpeaks as follows, in his eſſay on method. “But as I had propoſed to ſpend my whole life in the acquiſition of ſo neceſſary a ſcience, and fell upon a method, which I thought would enſure me ſucceſs in the enterpriſe, unleſs death, or a want of expements ſhould interpoſe; I judged the beſt thing I could do to remove theſe obſtacles, would be to lay before the publick a faithful account of all the advances I had made, however inconſiderable; and at the ſame time endeavour to perſuade men of extraordinary genius to purſue what I had begun, and make each of them in particular as many experiments as he could, and then inform the publick of every diſcovery made this way, that by the laſt beginning where their predeceſſors in this uſeful undertaking had left off, and then joining together the lives and labours of a great many, we might ſooner obtain our purpoſe, than could be done by the unaſſiſted endeavours of ſingle perſons. I have always found the more any perſon knew, the more he ſtood in need of making further experiments.”

The illuſtrious Boyle, to whom mankind is ſo highly obliged for his admirable writings, not only conſtantly endeavoured, and that with great labour and expence, to add to the number of uſeful experiments already made, and thence derive certain, and ſolid concluſions, but likewiſe ſtrenuouſly, tho' candidly, endeavoured to prove by the weightieſt arguments, the great uſefulneſs and neceſſity of experimental phyſiological. Theſe are his words, in his proemial eſſay to certain phyſiological eſſays.

“If men could be perſuaded to mind more the advancement of natural philoſophy, than that of their own reputations; it were not, methinks, very uneaſy to make them ſenſible, that one of the conſiderableſt ſervices that they could do mankind, were to ſet themſelves diligently and induſtriouſly to make experiments, and collect obſervations, without being over-forward to eſtabliſh principles and axioms, believing it uneaſy to erect ſuch theories as are capable to explicate all the phænomena of Nature, before they have been able to take notice of the tenth part of thoſe phænomena that are to be explicated. Not that I at all diſallow the uſe of reaſoning upon experiments, or the endeavouring to diſcern as early as we can, the confederations, and differences, and tendencies of things: for ſuch an abſolute ſuſpenſion of the exerciſe of reaſoning were exceeding troubleſome, if not impoſſible.”

But that I may at length conclude, the ſucceſs of my labours ſo apparent in every page of this work, proves abundantly all that I have advanced on this occaſion. For when I conſider within myſelf, that by the help of experiments, I have here been able to diſcover things, which not only men of moderate parts, but even the greateſt geniuſes, from the age of Ariſtotle, to the preſent, during an interval of about two thouſand years, have in vain endeavoured to find out, I cannot but look upon this happy reſult of my labours as the beſt proof of the ſuperior excellency of experimental philoſophy. Nor is there here any occaſion for a great parade of words to demonſtrate the abſolute neceſſity of diligently examining things in themſelves; for if our juſteſt reaſonings ought to terminate in experiments, to be built upon experiments, and purſue the courſe preſcribed us by experiments, who is there, that would not, in forming his judgment of things, much rather truſt to experience, then to the idle fancies of his imagination; nay, I may aſk, who will hereafter dare to affirm, that we may depend upon our reaſon alone, to come at the knowledge of every kind of truth? whereas it is moſt certain, that by making a proper uſe of our ſenſes, we may from the things we ſee, gather ſufficient information concerning thoſe that we cannot: the end of the general and particular treating of inſects, all which I have reduced to four orders, and proved to reſt upon one ſingle foundation, which is the Nymph.

A General Analogy, or Compariſon of the

MUTATIONS and ACCRETIONS

As to PARTS and LIMBS,

As well in Eggs, Worms, and Nymphs, as in Inſects among themſelves:

Alſo in thoſe Mutations, and Accretions which we obſerve in an Animal of the red-blood Species, and a Vegetable clearly exhibited at one View.

Tab. I.	Tab. XII.	Tab. XVI.	Tab. XXXIII.	Tab. XXXVIII.	Tab. XLVI.	Tab. XLVI.
First Order.	Second Order.	Third Order. Firſt Species.	Third Order. Second Species.	Fourth Order.	The Frog.	Caryophyllus, or Clove July-flower.
I. The Louſe in its firſt ſkin, within which it is called a Nit.	I. The Worm of the Libella, or Dragon-fly, in its firſt ſkin, within which it is called an Egg.	I. The Worm of the Ant in its firſt ſkin, within which it is called an Egg.	I. The Caterpillar of the Phalæna or Moth in its firſt ſkin, within which it is called an Egg.	I. The Worm of the Fly in its firſt ſkin, within which it is called an Egg.	I. The Worm of a Frog in its firſt ſkin, within which it is called an Egg.	I. The Germe of the Caryophyllus in its firſt coat, within which it is called a ſeed.
II. The ſaid ſkin, or coat thrown off.	II. The ſaid ſkin, or coat thrown off.	II. The ſaid ſkin, or coat thrown off.	II. The ſaid ſkin, or coat thrown off.	II. The ſaid ſkin, or coat thrown off.	II. The ſaid ſkin, or coat thrown off.	II. The ſaid coat thrown off.
III. The Louſe diveſted of its ſaid ſkin.	III. The Worm of the Libella diveſted of its ſaid ſkin.	III. The Worm of the Ant diveſted of its ſaid ſkin.	III. The Caterpillar of the Phalæna diveſted of its ſaid ſkin.	III. The Worm of the Fly diveſted of its ſaid ſkin.	III. The Worm of the Frog diveſted of its ſaid ſkin.	III. The Germe of the Caryophyllus diveſted of its ſaid coat.
IV. The Louſe more grown.	IV. The Worm of the Libella more grown.	IV. The Worm of the Ant more grown.	IV. The Caterpillar of the Phalæna more grown.	IV. The Worm of the Fly more grown.	IV. The Worm of the Frog more grown.	IV. The Germe of the Caryophyllus more grown.
V. The Louſe conſidered as an Animal-Nymph.	V. The Worm of the Libella changed into a Worm-Nymph.	V. The Worm of the Ant changed into a Nymph.	V. The Caterpillar of the Phalæna changed into a Chryſalis.	V. The Worm of the Fly changed into a Vermiform-Nymph.	V. The Worm of the Frog changed into a Tadpole.	V. The Germe of the Caryophyllus changed into a Follicle or Nymph.
VI. The Louſe full-grown, and in a condition to propagate its ſpecies.	VI. The Libella full-grown, and in a condition to propagate its ſpecies.	VI. The Ant full-grown, and in a condition to propagate its ſpecies.	VI. The Phalæna full grown, and in a condition to propagate its ſpecies.	VI. The Fly full-grown, and in a condition to propagate its ſpecies.	VI. The Frog full-grown, and in a condition to propagate its ſpecies.	VI. The Caryophyllus full-grown, and in a condition to form its ſeed.

APPENDIX.

The anatomy of the * *Sea-Sepia or Cuttle-Fiſh. Inſcribed to the moſt excellent Francis Redi, phyſician to the great Duke of Tuſcany, a moſt indefatigable ſearcher into the miraculous works of Nature.*

THE INTRODUCTION.

THERE is not among the ſoft fiſhes, which are ſaid to have no blood, any that claims our attention ſo much as the Sepia or Cuttle-fiſh; as well on account of its external figure, which is wonderful beyond all deſcription, as for the ſtructure, order, and diſpoſition of its internal parts, which moſt evidently ſhew themſelves the work of infinite wiſdom. I ſhall not ſpeak of the common miſtakes and errors of the generality of mankind concerning this creature, much leſs attempt to cenſure thoſe eminent writers, who before me have treated of this ſubject; for every one of them wrote of natural hiſtory according to his own genius and fancy. I chooſe rather to exhibit in a few words the external and internal parts of this extremely ſingular animal. And whilſt I do this, I appeal for the truth of my relation to the reader's own eyes, by deſiring him to inſpect the creature itſelf. Certainly, thoſe who would avoid being impoſed upon, ſhould ſtudy nature in herſelf; for ſo many fallacies and errors have crept into the writings of preceding ages, that people cannot but be led aſtray by them, as often taking things upon truſt, they neglect to ſee for themſelves. This will evidently appear by the following hiſtory, which, tho' a new relation, does no more than exhibit in a new dreſs the truth itſelf, than which nothing can be more ancient.

The Sepia or Cuttle, is a creature that has eight legs, two long arms or claws, a ſhort head, very large eyes, and the beak of a Parrot. The body is ſomewhat oblong, conſiderably broad and thick; and the back is prettily marked with ſeveral whitiſh furrows, and elegantly dotted. The Sepia or Cuttle is frequently found dead on the Dutch coaſts in the ſummer months; it was there I firſt met with ſome of them, and made drawings of their viſcera. But the hiſtory I am now about to give, is no more than a bare narration of what I obſerved in two of them, which were brought me from the ſea about the middle of May, and of which I took ſhort notes and drawings, in great haſte, during four days that I ſpent in this inquiry.

The moſt conſiderable parts of the Sepia, which firſt offer themſelves to our view, are its legs and arms or claws. The legs to the number of eight, are ſeated round its mouth. The two forefeet, Tab. L. Fig. 1. *aa*, are very thick, and appear broad, when the fiſh lies flat upon its belly. The other ſix are very like one another in ſize and form. One ſide of all theſe feet is covered with a common ſkin, which is pretty ſtrong, and of a purple colour interſperſed with many black ſpots; beſides which, the two larger legs are marbled as it were with ſome white furrows *b*.

But the moſt remarkable thing in theſe legs, is their being all thick ſet with a prodigious number of particles like flattiſh but hollow globules, and each fixed to a kind of ſtalk *ccc*; Yet the extremities of the arms or claws, to which authors have given the name of Promuſcides, are ſtill more largely furniſhed with theſe kind of tubercles. Theſe brachia or arms are very long, if compared with the legs, and they are placed near the bill or beak, in the midway between the broadeſt pair of legs, and the pair next to it *dd*. They are of a cylindrical figure, and of a white colour intermixed with black and purple ſpots. The ſubſtance of them, as well as that of the *xx* legs, is ſoft; and they have the ſame kind of ſkin, but it covers them all over, which is more than it does in the legs. The extremities of the legs and arms are pretty much of the ſame form, only that the tubercles of the arms are larger, and the ſtalks upon which theſe tubercles grow much longer and ſtronger than thoſe of the legs *e*. The extremity of one of the arms is always larger than that of the other.

As theſe globules are hollow, authors have thought proper to call them Acetabula or ſawcers. Rondoletius tells us, that this ſtrange fiſh can faſten itſelf by its arms to any body it meets with, in the ſame manner as cupping-glaſſes ſtick to the ſkin by a kind of ſuction. And certainly this is a very juſt compariſon, as appears from the moſt wonderful contrivance of theſe parts, which I ſhall preſently deſcribe.

It is to be remarked, that the ſame kind of ſkin which covers the under ſurface of this animal's eight feet, does not extend to the upper; it goes no further than the globules *fff*, and there it forms a looſe border to the feet, which when the creature ſwims, floats in the water. For this reaſon, that looſe ſkin can cover all the ſurface of the feet, and their acetabula at the creature's pleaſure, as the edges and corners of a cloth, may fold over any thing that is laid upon it. Nor is it to the middle and baſis of the legs only that it performs this office, but even to their ſharp ends, where the acetabula *gg* are ſmaller than in any other part. But theſe borders are more conſpicuous about the extremities of the arms than elſewhere; for which reaſon I have repreſented thoſe belonging to one of the arms *hh*, as they appear when they cover the globules, except its being a little turned back.

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* The Sepia or Cuttle-fiſh is one of the animals of the ſixth claſs in the Linnæan ſyſtem, which he entitles Vermes: it comes under the ſecond order, to which he has given the name Zoophyta, and is arranged with the Star-fiſh and Polype. The characters of the genus are theſe; the body is oblong and depreſſed, the feelers or tentacula are ten, and two of theſe are much longer than the others, and have a kind of foot-ſtalks. Beſide the Cuttle-fiſh, this genus comprehends the Loligo, which the French call the Calamarie, and the Octopedi deſcribed in the Upſal-tranſactions. Of the Calamary we ſhall have occaſion to ſpeak largely hereafter.

The ſkin which ſpreads itſelf over the intervals of the globules, and covers the inſide of their ſtalks, and even the external ſkin's borders which I juſt now mentioned, is in ſome meaſure as it were muſcular, and is of a much more delicate texture than the other skin. It muſt likewiſe be obſerved that the parts ſupporting the acetabula tho' called ſtalks, are not really ſuch, but pretty conſpicuous muſcles adminiſtring to the acetabula.

I have obſerved alſo, that theſe little muſcles are here and there diſtributed over the inſide of the borders of the external, ſo as to be able to move thoſe parts as well as the acetabula. For this reaſon I conſider what is called the skin in theſe places as a muſcular ſubſtance.

I have repreſented ſome of the muſcles belonging to the acetabula of their natural ſize, in order to give the reader a more juſt idea of them. Tab. L. Fig. 11. N°. 1. ſhews, how the muſcle is inſerted underneath into the baſe of the globule, where it is ſomewhat hollow; and how by expanding itſelf, and then contracting again a little, and afterwards expanding itſelf again, it in a manner entirely forms the globule. For as far as I could inform myſelf by diſſection, the acetabula are altogether muſcular, and the tendons of thoſe muſcles are inſerted into a ring of a ſubſtance between horn and bone, which lies between the moving fibres of every acetabulum.

It appears, on examining the upper ſide of the acetabulum, and the ſtructure of its hollow, N°. 2. that it is likewiſe muſcular in theſe places; the little ring now mentioned ſhews itſelf very plainly on this occaſion. The upper edge of this ring is generally black, but this blackneſs is only ſuperficial, being no more than a portion of the external coat of the globule, and therefore it may be eaſily removed.

By taking out this ring, and placing it on its ſide, N°. 3. we obtain a good view of its conſtruction, and the blackneſs of its upper edge; we even diſcover by placing it in this ſituation, in what manner it is perforated in the middle, and its upper and lower edges waved in a ſerpentine manner. This conſtruction, ſo well contrived for receiving and holding the muſclar fibres, wonderfully contributes to keep the ring firm in its ſituation.

The better to ſhew the black edge of this ring, and the manner in which it is turned, I have repreſented it, N°. 4. in a convenient ſituation to ſhew all its upper circumferences: and have added a ſmall ſegment of it, N°. 5. to make the conſtruction of this part as intelligible as I poſſibly could; for it would be extremely difficult to underſtand the uſe of this ring, without knowing exactly in what manner it is formed.

The advantage of this ſingular conſtruction conſiſts in this, that the muſcular fibres of the acetabulum can by contracting themſelves raiſe the ſtalk or muſcle of the globule very high within the cavity of the ring, and thereby of courſe ſtreighten the cavity of the acetabulum, whilſt on the other hand the muſcle of the ſtalk, by exerting itſelf at the ſame time, again raiſes itſelf and its fibrous parts out of the globule, ſo as to make its cavity much wider and more ſpacious than it was before.

Nor do I in the leaſt doubt, but all the Cuttle-fiſh's power of faſtening itſelf to bodies, or taking hold of, and conveying any thing to its mouth, depends entirely on the ſingular conſtruction, and exertion of the part juſt now deſcribed. Whenever this ſtrange animal applies to any body that prodigious number of globules, with which its arms and legs are furniſhed, and then immediately withdraws the muſcular ſtalks of theſe globules, from within the hollows of the acetabula, taking care at the ſame time, not to let any water into theſe cavities, the water repelled in this manner muſt preſs ſuch parts againſt the body, againſt which they lie, with an extraordinary force: And this end is the more certainly obtained, as the borders of the ſkin which covers the arms and legs are likewiſe muſcular; and by containing and encloſing the globules at the time of their action, contribute greatly to hinder any water from inſinuating itſelf within the cavities of the acetabula.

We muſt therefore be more than blind, not to diſcover by this ſingle inſtance, how wonderful God is in his works, ſeeing he has here effected, by means of repelled water, ſuch a ſuction (to make uſe of a common expreſſion) as he has produced by means of repelled air in the vital element we breathe. Hence alſo we may eaſily underſtand, what Rondoletius ſays of the brachia or arms of this animal; and of the manner wherein it remains in the moſt ſtormy weather immoveably fixed, and as it were at anchor at the bottom of the ſea; for at ſuch times no doubt it dilates its acetabulum to the utmoſt breadth, and faſtens itſelf in its poſt, by their means with an extraordinary degree of power.

The beak, Tab. L. Fig. 1 *i*, which lies in the center of the legs, is like that of a Parrot, and conſiſts as it were of two maxillæ or jaws, both moveable. Theſe maxillæ join each other in the ſame manner with the body and the lid of a box, when the former ſlides up within the latter. The fleſh which ſurrounds this beak, inſtead of lips *k*, is regularly orbiculated and ſometimes appears plaited or folded back in wrinkles, like a purſe that has a border to it.

Under the beak and legs appears the head, in which the eyes *ll* are very conſpicuous. The moſt remarkable part of theſe is the cornea, which lies upon them ſo looſely, that it may in a manner be moved backwards and forwards like the membrana nictitans or winking membrane in birds. The operculum *m m* of the pupil, makes its appearance very elegantly thro' the cornea, which is tranſparent: but this operculum does not appear any where to ſo much advantage as in the Ray-fiſh, as Stento has moſt exactly deſcribed it. I have likewiſe diſcovered this operculum of a black colour in the eyes of horſes; at one ſide of the eye, the pupil projects a little, nor is it exactly round in this place. On drawing this operculum over the pupil, the eye loſes its ſight. Some time ago, I obſerved that the crocodile has a cat's eye, having an aperture to its pupil, which in the day-time reſembles a long ſlit.

The Cuttle-fiſh's neck is very ſhort, and like the head is elegantly covered with black ſpots upon a purple ground. The upper extremity of the back *n* riſes by a remarkable proceſs over the neck; ſo that the creature can hide its head under it, in the ſame manner that the naked Snail hides its head under its verge or border.

All the parts of the Cuttle-fiſh, yet mentioned, are ſoft, except the beak, and the cartilaginous rings of the acetabula. But the back is hard, firm, and incapable of motion, as the bone of the creature lies here, running quite thro' the back to the tail, without any vertebræ or like diviſions. The muſcles of the creature are inſerted into this bone. That part of the body which lies at the two ſides of the bone, is ſoft and muſcular *o o o o*, which makes it probable, that this extremity, which terminates the back and belly of the Cuttle-fiſh, may be of great uſe to it in ſwimming. The back-bone alſo is well contrived to anſwer the ſame purpoſe, for it floats on the ſurface of water, even when it is juſt taken out of the ſea, and before it has had time to loſe by drying any of thoſe pieces, which may be ſuppoſed to make a conſiderable part of its weight.

The colouring of the back afforded a very entertaining ſight, for its ſurface was raiſed with a great many white ſtreaks and furrows like ſo many veins interſperſed with very ſmall black ſpots; but between theſe ſtreaks the ſkin was of a deeper colour, and marked with larger black ſpots. Where the ſtreaks ended, there appeared a great number of white ſpots, which were either round or oval, even the extremities of the ſtreaks were either round, or ſhaped like a pear. The ſoft margin of the body was of a ſomewhat deeper purple, ſprinkled with ſmaller black ſpots, and ſome others that were round and white; but it then grew whiter towards its extremity, where it ended in a deep purple edge. On the hinder part, where in other animals are ſeated the arms and tail, the margin was ſomewhat divided or dented in, *p*; ſo that from this nick, the body of the Cuttle-fiſh appeared naturally divided into a right and left ſide.

On handling the beak a little, it fell from the head, which gave me a very convenient opportunity of examining its ſubſtance, colour, and conſtruction. The ſubſtance of this part is between bone and horn, and thicker and more compact on its upper part, with which the animal bites, but on the lower, to which the muſcles of the beak are fixed, more tendinous and membranaceous. In figure it reſembles the Hawk's or Parrot's beak, and has many things in common with it. The upper part, which, as I ſaid before, in the thickeſt, is of a deep brown colour, which grows redder and redder in proportion as the beak grows more and more membranaceous. But as the beak conſiſts of two maxillæ or jaws, an upper and a lower, which meet together, and move one upon and towards the other, ſo likewiſe they differ in conſtruction. The lower part ſpreads as it were into two wings Fig. III. *aa*, between which the upper part ſinks, and ſo meets this lower. The lower maxilla, or jaw, is on its hinder part folded back within itſelf *b b*, not unlike a paper tube bent back, by which means its ſharp extremity becomes twice as thick and ſtrong as it would otherwiſe be. On the lower part it bends itſelf back, ſo as to form a hollow furrow *c*. This beak appears altogether fibrous, and ſeems to be compoſed of membranaceous tendons, hardened by degrees into a horny bone. The upper jaw of the beak *d*, is of the ſame ſubſtance with the lower, from which it only differs in its curvature and form; beſides, its internal ſinus is much more deep and broad *e e*, to afford the tongue, which lies in this ſinus, the greater liberty to move itſelf. The muſcles alſo find better inſertions in the hollow ſinuſes of this horny bone, in whoſe membranaceous expanſions they are fixed.

The tongue, which is thought to be a fungous ſubſtance, conſiſts of ſeven little cartilaginous bones, which lie very cloſe to each other, and are beſides united by means of a particular membrane. The upper extremity or point of the tongue is ſomewhat crooked Fig. IV. *a*, but the lower part is united with ſome muſcular and fungous fleſh, in which it lies, as in a hollow tube. This fleſhy portion of the tongue is full of wrinkles and elegant folds *b*, which ſeem to contain a great many ſmall ſalival ducts. I have found by diſſection that a very conſiderable ſalival duct *c* opens and diſcharges into this fleſhy part.

This ſalival duct deſcends by a long tube, *d*, through the animal's neck into its breaſt, where it divides into two branches, that terminate in two very conſiderable glands, *e e*. Theſe glands ſeem, on nice inſpection, to be of the kind called conglobate, or by anatomiſts, though externally, they appear of the other kind, known by the name of conglomerate. On opening them, I found a kind of hollow in them, made to receive the ſaliva, ſecreted by their fungous ſubſtance; but I could not diſcern the ramifications of theſe two parts, which, no doubt, ſpread themſelves through the parenchyma or fleſhy ſubſtance of their glandules; but the coloured liquors I injected, ſhewed no ſuch thing. Theſe glands lie within the breaſt, on each ſide of the gullet or throat, in ſuch a manner, that this laſt channel runs above and between them: this beſt appears on opening the body of the fiſh, after turning it upon his back. The tongue and parts belonging to it, when taken out of the beak, generally bring along with them ſome of the muſcles, two of which, *f f*, I have here given a cut of. But I return to the tongue.

The contraction of the tongue, which, as I have ſaid, conſiſts of ſeven cartilaginous bones, becomes very viſible on parting it from the fungous fleſh to which it is faſtened, and in which it is wrapped up; but it may be made ſtill more conſpicuous, by drawing off the membrane, Fig. V. *a*, with which the inferior part of the tongue is covered, and afterwards ſeparating from each other with a fine knife, at the extremities, the little cartilaginous bones, of which it conſiſts, *b*. After treating the tongue in this manner, we may ſee by the microſcope, that every one of theſe bones is furniſhed with above ſixty crooked cartilaginous papillæ, Fig. VI. *a*, in form of teeth, and in ſome meaſure reſembling the papillæ on the tongues of black cattle. By theſe the Cuttle-Fiſh, when feeding, is the better enabled to move its food, and diſpoſe it for an eaſy ſwallowing. The fore-part of theſe papillæ, is of a clear and tranſparent amber colour, but the hinder-part, which conſtitutes the baſe, or root of the tongue, is of a tranſparent white. The beſt way to examine the tongue, is to invert it, and then ſurvey it with a microſcope on the under or lower ſide, where its baſe or root lies; for, by this means, we diſcover, that in ſtructure it exactly reſembles the moſt regular web, Fig. VII. *a a*, from the frame, or combination of the cartilaginous bones already deſcribed. The ſight of this admirable contrivance, induced me to take out the tongue and dry it; but all its beauties vaniſhed almoſt entirely in the operation.

The body of the Cuttle-Fiſh, when laid on its back, appears much whiter, and has by far fewer ſpots. But the moſt remarkable thing in this animal, is an opening in this under part of its body, in which an expanded hand may be entirely buried: this is between the body and the muſcular partition that covers it on its fore-part.

On opening this lower part of the body, Tab. LI. Fig. I. *a a*, in a right line through the middle of the belly, *b b*, from the beginning of the breaſt to the tail, *c*, and this without injuring the contents; there immediately appear ſeveral remarkable internal parts, ſome quite plain and naked, and others appear more faintly, as lying deeper in the breaſt and belly, and only ſhewing themſelves through ſome interpoſing tranſparent membranes.

The firſt thing which preſents itſelf here, is a bag or bladder lying in the ſuperior region of the breaſt, which I call the common excretory bag, or bladder. The colour of this part is white, its ſubſtance is muſcular, and its ſhape is like that of an inverted funnel, very ſpacious and broad at the bottom, *d*, and ſlender at top, *e*, it joins on each ſide with two oval cartilaginous, muſcular and hollow little bodies, *f f*, which ſerve to receive theſe two greater papillæ, or cartilaginous eminencies, *g g*, which I have repreſented, one on each ſide of the muſcular partition, looſely ſurrounding the contents of the belly, and cut away by me upon this occaſion. By this junction of the excretory bladder, and theſe oval bodies, it is provided, that nothing ſhould move ſoon, or be diſcharged by the inferior parts of the body, without paſſing through this excretory bag; and the ſame wiſe diſpoſition of theſe parts, keeps the Fiſh's eyes from being injured by the excrements, ſperm, eggs, and black liquor, which all make their way through this funnel, as they certainly would, if theſe diſcharges were to be made between the funnel, and the muſcular partition of the body: for this reaſon alſo, nature has formed this bag or bladder of a muſcular ſubſtance, the better to diſcharge its contents at the creature's pleaſure.

As yet, I cannot ſay for certain, whether or no the papillæ juſt ſpoken of, are naturally and conſtantly united with the oval acetabula, which I have deſcribed; for I have ſometimes found them independent and disjoined. But as I could never find in theſe parts, the leaſt mark of any rupture or fraction, the acetabula, on the contrary, always appearing quite ſmooth, and the papillæ of a bright poliſh; I think it very probable, that the Cuttle-Fiſh has a power allowed it by nature of joining and ſeparating theſe parts, as neceſſity requires.

The office of thus joining and ſeparating theſe parts, I am inclined to attribute to a pair of compact, oblong, white muſcles, Fig. I. *h h*, which at their upper extremities unite with the acetabula, and are contained within the lower edge of the excretory bag or bladder. Theſe muſcles are among the parts, which appear naked in the breaſt, without any previous diſſection. Nor do I ſee any uſe they can be of except that which I have aſſigned them, of joining and ſeparating the acetabula, and the papillæ, by doing which, the excretory bag or bladder is at the ſame time dilated, ſo as to facilitate the diſcharge of its contents through the funnel already mentioned.

Hence, it is impoſſible to thruſt all the hand in the manner beforementioned, into the Cuttle-Fiſh's body, without firſt ſeparating the papillæ from their acetabula.

On opening this excretory part, it appears compact and muſcular, and forms withinſide, on its lower part where it joins the breaſt, a kind of lobe in the ſhape of a broad tongue.

The other parts that appear in this place, without further diſſection, are the gills, *i i*, of a ſoft ſpungy ſubſtance, placed on the two ſides of the body, and forming a very agreeable appearance, on account of the extreme whiteneſs of a great number of blood-veſſels, with which they are provided; and the colour of theſe veſſels is greatly heightened by the greeniſh hue of the gills through which they run.

Examining one of theſe gills, I found in only half of it more than forty diviſions or ramifications of the greater blood-veſſels; that is more than eighty to a ſide. But if we conſider alſo the prodigious number of theſe ramifications, which penetrate into the ſubſtance of the gills, Fig. I. *k*, where the muſcles adminiſtring to theſe parts likewiſe run, we ſhall have reaſon to think the number of theſe ramifications is almoſt infinite.

Words cannot do juſtice to the contrivance, order, invention, and moſt elegant conſtruction of theſe parts; ſo that my figures deſerve only to be conſidered as the faint ſhadows of their perfection. The gills are membranaceous underneath, near the roots, where they end in a ſlender ſtalk, as it were, and are faſtened, as appears, by a pretty ſtrong ligament, *l l*, though as yet, I am not ſure but this ligament itſelf, may be compoſed of blood-veſſels, not having had ſubjects enough to examine theſe parts ſo much as they deſerved. On opening the diviſions of the gills, this ligament makes a pretty appearance; at the ſame time, that we may diſcover how theſe parts grow more and more ſlender towards their roots, *m*.

Indeed the conſtruction of the gills is more apparent in other kinds of fiſh, whoſe blood is red; for in ſome we meet with cartilages, and in others real bones, over whoſe ſurface the blood veſſels are diſtributed. This circumſtance I formerly moſt evidently diſcovered in the Sturgeon, the Whiting, and other fiſhes, by injecting their blood veſſels according to a method peculiar to myſelf, and of my own invention. This I could diſcover, and I ſaw it with the greateſt aſtoniſhment, that the contrivance, ſtructure, and order diſplayed in theſe parts by the ſupreme Architect, and diſcoverable by thoſe who love to contemplate Him in his works, were infinite in perfection and number, as I ſhall hereafter endeavour to prove by deſcribing and delineating ſome of them by way of ſpecimen of the reſt. In the mean time, I can ſhew the curious the parts themſelves injected by me with wax of ſeveral different colours.

In that part of the Cuttle-fiſh's body, which I conſider as the thorax, there is a protuberance, Tab. LI. Fig. I. *n*, by naturaliſts called mutis. Upon this part there is always found lying an open pipe, quite looſe, ſo as not to be confined to any one place *o*, but floating freely in the body. This pipe is, properly ſpeaking, the animal's rectum, or ſtraight gut. It has alſo a remarkable aperture at its end, by which the fiſh diſcharges its inky liquor from the bag contrived by nature to contain it. This bag lies in the lower region of the belly, where it ſhews itſelf thro' the tranſparent interpoſing parts *p*. Near the lower part of the ſtraight gut there are two more ſhort, open-mouthed tubular channels *q q*, for the diſcharge of the ſeminal matter, the veſſels of which lie under theſe channels, with an extuberant membrane between them *r*. Lower down in the ſtomach *s*, and under the ſtomach, a certain little particle or body *t*, belonging to the ſpermatick veſſels, ſhews itſelf thro' the tranſparent parts that lie over it.

In that part of the body where the extremity of the ſtraight gut floats looſely on the right, there is on the left another looſely-floating tubular aperture *u*, thro' which the teſticle itſelf diſcharges its ſperm, which is afterwards to be carried off into the water, thro' the common excretory duct. This teſticle is placed with its vas deferens, on the left ſide under the gills *x*, and ſhews itſelf faintly without diſſecting the parts that cover it.

It is now time to give a more complete enumeration of all the parts hitherto mentioned, with a fuller deſcription of them; and the figures will make it ſtill more intelligible: this I ſhall do, after having firſt taken ſome notice of the parts of the Cuttle-fiſh belonging to its head, which lies upon the back. It is here that we ſee its beak, and the muſcular circumference of its mouth *a*, which I have here repreſented a little leſs than nature; but in every thing elſe perfectly agreeable to the life. But, not to make my drawings too large, I have taken the liberty of curtailing the legs, and the two arms in this figure ββ, which I have exhibited in their natural ſituation and poſture. I have likewiſe taken great care to ſhew exactly in what order the acetabula are placed on the two fore-legs, when the muſcles of theſe acetabula are contracted; for it is an eaſy matter to procure a ſight of them in this ſtate, even in a dead fiſh. This is done by cutting ſome of them off, with part of the leg to which they belong, and then dipping the whole in boiling water; for in leſs than a minute they become perfectly contracted.

I likewiſe give a drawing of theſe muſcles with their acetabula, as they appeared at the extremity of one of the arms, which I had ſtripped of its internal ſkin; ſo that their inſertion and conſtruction, Tab. LI. Fig. II. *a*, may, by this means be very diſtinctly ſeen, as likewiſe the order in which the acetabula themſelves are united with their muſcles *b*. It likewiſe appears by this figure, that both the acetabula and their muſcles, are much larger about the middle of the arms than at either of their extremities *c c*.

I have thought proper to repreſent in a ſegment of one of the larger legs, that lie over the head, Fig. I. γγ, the internal ſtructure of the legs themſelves. Their texture on the outſide is fibrous and muſcular; but within-ſide it is a little more fungous. In the middle of them there appeared ſomething that I took for a blood-veſſel, and I have here repreſented by a black dot δ.

To take a ſurvey of the Cuttle-fiſh's inſide, it is neceſſary to cut away the common excretory duct, and the muſcles which move its two acetabula, and then very cautiouſly to open that part which I call the thorax, and raiſe from it its membranaceous covering. This done, there appears the looſe fungous body, called mutis by naturaliſts, and thought by them to have a great reſemblance to the liver. I have always found this mutis regularly didivided into very diſtinct parts. The upper part is very thick, and with gentle treatment it may on each ſide be eaſily parted into two lobes, Fig. III. *a*. Otherwiſe, on wounding the coat that inveſts it, its ſubſtance readily flows off, being exceeding ſoft, and like a liver bruiſed by an anatomiſt, in order to extract its parenchyma, or pulpy ſubſtance. In the middle this mutis is very thick and ſpungy, and at its lower extremity conſtantly ends on each ſide in an obtuſe appendage *b b*, which extends to the belly. The upper end of this organ lies in part on the throat, which lies itſelf alſo on the ſalival glands, Fig. V. *b b*, and thus runs under the mutis to the ſtomach. Under the throat appears the great artery, which riſing upwards from the abdomen (where this animal's heart lies) ſends to the mutis two conſiderable branches, Fig. III. *c c*, that iſſue from thence, as if they deſcended from the thorax. The greateſt part of this body lies upon the bone of the fiſh, on each ſide of the bone, and of the great artery, and it is only divided from the bone by a kind of fibrous membrane.

After this, the courſe of the blood-veſſels running thro' the mutis, is diſcovered by opening and turning over, Fig. III. *d*, the membrane that encloſes it. But the ſubſtance of this part is ſo very ſoft, that by expanding itſelf like a liquid, it intirely hinders the view. This makes it neceſſary to ſeparate with a ſpatula this pulp from the veſſels that go thro' it, and afterwards thoroughly waſh the veſſels themſelves with water. Thus, at length, a ſatisfactory ſight may be obtained of the diſtribution of the blood-veſſels, Fig. IV. *e*. By this proceſs we likewiſe diſcover that the ſubſtance of this part is in a manner entirely compoſed of an infinite number of little grains, being looſely connected with the blood-veſſels *f*; but then a good microſcope is requiſite to diſtinguiſh theſe ſmall corpuſcles. The colour of the mutis is between red and yellow, ſomewhat inclining to a brown. I cannot determine what the uſe of it may be; it lies entirely by itſelf, within a peculiar membrane, and conſiſts of two diſtinct bodies, without having the leaſt reſemblance to the liver, as heretofore idly pretended. Nevertheleſs, I cannot take upon me to deny its performing the ſame office with the liver, as the wonders of nature are inexhauſtible, and God the maſter of nature has, in different animals, formed in a various manner organs ſubſervient to the ſame purpoſes; this will evidently appear by the ſurpriſing ſtructure of the genital parts of this animal, which are contrived with an art and elegance that ſurpaſſes all deſcription.

The throat, as I ſaid before, runs under the mutis, and has its origin in the ſame place nearly where the fauces terminate. By the fauces, I mean that wrinkled and muſcular part of the ſkin, which reaches from the beak and mouth, Fig. V. *a*, to the beginning of the gullet, or that tube which runs from the mouth to the ſtomach. This gullet paſſes under the brain, and then deſcending into that part of the body, which I call the thorax, it there lies ſoftly upon the ſalival glands *b b*, and is connected with the two already taken notice of; from whence it runs in a ſtraight line to the abdomen, where it opens into the ſtomach *c*. The ſtomach reſembles in a manner a ſpherical bag; but it is ſomewhat indented in the middle. There run thro' it a great many blood-veſſels *d*, which are ſeen the better by injecting the arteries with ſome coloured ~~liquid~~. This organ conſiſts of three coats; the external coat is membranaceous; the middle coat muſcular; and, as to the internal coat, it readily ſeparates from the middle coat with the food it immediately encloſes, and ſo may be eaſily taken out of the ſtomach with all its contents.

The Cuttle-fiſh, I could obſerve, feeds upon Shrimps; for there remained in its ſtomach the eyes, legs, and tails of Shrimps, with ſome of the rings of their bodies. I could diſcern alamong theſe, remains of the back-bones and ribs of ſome very ſmall fiſhes.

The ſtraight gut, Fig. V. *e*, iſſues immediately from the ſtomach, and is the only inteſtine I could diſcover in this animal; ſo that the veins muſt take the aliment immediately from the ſtomach, and then convey it to the heart, whoſe buſineſs it is to diſtribute it over the whole body.

Under the ſtraight gut lies an appendage of the ſtomach, into which it opens by a particular orifice, after twiſting like a ſnail in a very remarkable manner *f*. I cannot ſay for certain what this part may be; tho' to judge anatomically of it, I ſhould take it for the pancreas, which, except its not being twiſted, appears of the ſame conſtruction in a great variety of fiſhes, as may be ſeen in a treatiſe of mine on that part of the creation, adorned with figures, printed by Commelyn of Amſterdam, and dedicated to the College of Phyſicians of that city. This organ is very ſmooth and ſlippery on its inſide, and contains a matter like the pancreatick juice of other fiſhes.

The white bag which contains the Cuttle-fiſh's ink *g*, lies principally in the left ſide of the body, and communicates by a ſlender channel with the upper extremity of the ſtraight gut *h*; ſo that both the fæces and the ink are diſcharged thro' the ſtraight gut by one and the ſame orifice. This bag is in part membranaceous, and in part muſcular; and is furniſhed with blood-veſſels, which run over its ſurface *i*. Within I diſcovered a little glandulous body, or maſs, which perhaps ſerves to generate or prepare the ink; for I had not opportunity to examine it thoroughly, on account of the ink's flowing ſo conſpicuouſly, that it was impoſſible to waſh it off faſt enough to obtain a ſatisfactory view of this organ.

It is therefore neceſſary not to wound this part on diſſecting the Cuttle-fiſh, as by pouring out its contents it would infallibly render all the other parts inviſible. The ink contained in one bag is ſufficient to communicate a blackneſs to ſeveral pails of water, ſo intenſe is its colour. I ſhall not pretend to ſay abſolutely what the uſe of this ink may be; or whether or no it may ſerve to obſcure the ſurrounding waters, and thereby ſecure this animal from other fiſhes which would devour it; for, as yet, I have had no experience in this matter. But it is certain that the Cuttle-fiſhes I found dead on the ſea-ſhore contained a greater quantity of this ink than thoſe which were brought to me alive. The liquid is inſipid to the taſte, without the leaſt ſowerneſs or bitterneſs; ſo that I cannot ſee how this inſipid ſubſtance, by being boiled with the Cuttle-fiſh, can in the leaſt contribute to give it an extraordinary reliſh, as thoſe pretend who feed upon it; tho' the moſt general manner of uſing this fiſh, is barely to give it a drying in the open air.

The ink taken out of its bag, and poured into a glaſs coagulates and grows hard in a few days, when it ſeparates into a great many little pieces, which, ground upon a ſtone, afford the moſt elegant black paint. This convinces me that the Indians prepare their ink with nothing but this juice. I have even obſerved that this ſubſtance, while in a liquid form, ſtruck ſo ſtrong a black, that no waſhing could get it out; as particularly appeared in a black coat made of a ſlight dutch cloth, which had ſome yellow ſtains from aqua fortis: near the ſtomach, and between the folds of the pancreas, there lies a glandulous body, which runs to the throat, Tab. LI. Fig. V. *k k k*; but I am as much in the dark, as to its uſe as to that of the ink-bag; tho' I think it belongs to the organs of generation, which I ſhall hereafter take notice of, having firſt deſcribed the heart, brain, and nerves; and likewiſe ſaid ſomething of this creature in particular.

The heart of the Cuttle-fiſh, contrary to what we obſerve in moſt other animals, lies in the abdomen, Tab. LII. Fig. 1. *a*. It is of an oblong triangular form, and in colour very like a muſcle that has neerly loſt all its blood. Its external ſurface is tolerably ſmooth and even, and its internal one fibrous, and divided into little hollows, and prominent columns. I could diſcover but one ventricle in this organ.

The Cuttle-fiſh's heart has two auricles; for as the gills in this animal are placed on each ſide of the body, and at a great diſtance aſunder, nature it ſeems, has thought proper that, inſtead of one, this fiſh ſhould have two auricles *b b*, which I have here repreſented, as they appeared on ſeparating them from the blood-veſſels of the gills *c c*. They are of a membranaceous texture, and, when blown up, are of the ſame figure exactly with the deſign I give of them. I have no more at preſent to ſay of theſe parts; for they had almoſt eſcaped my notice when I happened to diſcover them; ſo that to acquire a thorough knowledge of them, I ſhould have had more ſubjects; which are not to be obtained without great trouble and expence, on account of the brutality and avarice of the fiſhermen, who ſell the produce of their hardeſt labours for nothing in a manner, whilſt they fix an extravagant price on ſuch things as come in their way without their being at the pains to look for them. In the mean time I muſt obſerve, that this fiſh's heart having but one ventricle, at the ſame time that it has two auricles in common with other animals, is altogether ſingular, and may well deſerve to be conſidered as a paradox. The blood of the Cuttle-fiſh is white, which is all I can ſay of it, as I never examined it; tho' I had reſolved to ſave ſome of it in a glaſs tube for microſcopical inſpection, and in order to find out its analogy to the red blood of other animals.

The great artery, which firſt riſes from the heart *d*, is of the ſame conſtruction with that of fiſh; but it grows ſomewhat ſmaller in its courſe, and ſends forth two pretty conſiderable branches, which immediately diſpatch leſs ones *e e* to the mutis, whilſt the others run to the muſcular parts of the reſt of the body; ſo that ſome of theſe ramifications are ſeen plainly thro' the tranſparent ſkin under the two muſcles, which move the acetabula of the common excretory duct, Tab. LI. Fig. 1. *y*; from whence they extend to the gills and ſeveral other parts. After this the artery formed into one trunk, ſtretches to the baſe of the brain, Tab. LII. Fig. 1. *f*, where it divides into various branches, ſome of which run thro' the cartilages, that encloſe the brains in place of a ſkull, whilſt the reſt diſtribute themſelves to the legs and other parts of the body. But it is yet unknown what is the courſe of the veins in this creature, and whether it has like fiſhes a firſt and ſecond artery, theſe are things I have not yet been able to diſcover; neither can I tell for certain, whether or not the two veſſels ſpringing from the lower region of the heart itſelf *g g*, and here moſt exactly repreſented by me after life, are really veins, as I think they are. But all theſe doubts may be cleared up by repeated diſſections.

The brain of the Cuttle-fiſh is very ſmall, and is plainly divided into a right and left portion, Fig. II. *a* To ſee this conveniently, it is proper to turn the animal on it's belly, then open its head, and cut away with a very ſharp knife the cartilages that contain the brain, uſing great caution for fear of injuring the nerves which iſſue from it. The brain lies on the back part of the head, in a manner entirely buried in fat, which I have here for diſtinction ſake repreſented by dots *b*. It is no eaſy matter to ſeparate this fat on every ſide without hurting the brain on account of it's exceeding ſoft and delicate texture. The optick nerves *c c* are likewiſe at their origin ſurrounded with fat; but in their progreſs, after running thro' the cartilages of the brain, they dilate into a conſiderable knot *d d*, which ſeparating into two tubercles, as it were, ſends thence towards the eyes a great number of nerves *e e e e*, as I have endeavoured to repreſent them one ſide. This numerous body of nerves is interſected by a conſpicuous blood-veſſel *f*, before they can reach the choroide tunic, or coat of the eye; which is remarkable for its great variety of beautiful colours; and is ſo inveſted with theſe little fibres, which embrace and ſurround the eye on every ſide *g*, and have a great ſhare in compoſing it, that this uſeful organ muſt receive great ſtrength from ſuch an acceſſion. About the upper region of the eye, where the iris ſhews itſelf in other animals, this coat forms in this a globular prominence *b*, from which a cryſtalline lens partly projects *i*.

I have thought proper to give a ſeparate drawing of the pupil's covering or lid, continued to the extremity of the choroide tunic; I firſt repreſent it on that ſide where it was cut from the eye Fig. III. *k*, and looks of a deep green colour, which by degrees grows paler, and is interwoven with delicate veſſels. I then exhibit its other ſide, by which it may be ſaid to float freely in the aqueous humour, and reſt againſt the cryſtalline lens. In this part it is of a ſilvery whiteneſs, and interſperſed with very delicate ſtreaks or fibres. Theſe fibres look as if they were continued not only to the filaments of the iris, but likewiſe to thoſe of the choroide tunic, which I have already repreſented. This covering or lid of the pupil is of an extreme blackneſs in that part of it, which lies over the ſuperior region of the cryſtalline lens.

I could find but very little of the aqueous humour on the inſide of the eye, whereas that conſtituting the cryſtalline lens was in conſiderable quantity, and was tolerably compact. But there was ſomething ſingular in this laſt part, namely, its coat's being of an extraordinary thickneſs, and likewiſe its ciliary ligaments penetrating ſo deep into the cryſtalline lens, that it in ſome meaſure as it were divided this part of Tab. LII. Fig. IV. *m*, the eye; this may be beſt ſeen on the fore part. On boiling this eye, and then pealing off the ciliary ligament, along with the coat of the cryſtalline lens; and likewiſe the fore ſegment of this lens from its back ſegment, the lens itſelf appears exactly like a globe contained in a ſemiglobe, or like a ſphere in a hemiſphere.

The vitreous or glaſſy humour was in a manner ſo perfectly fluid, as rather to deſerve the name of an aqueous than vitreous humour. I could not diſcern exactly the retina, as the black juice of the avea happened to get out of its membrane, and thereby ſpread an impenetrable obſcurity all over the adjacent parts. This accident for want of ſubjects, obliged me, to put an end to my anatomical ſurvey of the eye; and therefore I ſhall return to the brain, and the nerves that iſſue from it.

From the fore region of the brain, there ariſe three conſiderable pairs of nerves, which, after making their way thro' the cartilages of the brain, run in a moſt beautiful manner to the muſcles of the head, beak, legs, and adjacent parts. But the conſtruction of the middle pair is more admirable than that of the lateral ones, as it ſwells into a node or globule Fig. II. *n*, from which the nervous branches iſſue in a moſt elegant manner, like rays of light of the ſun's body.

The better to ſhew the ſituation of all theſe parts, I have given a particular engraving of the cartilages which ſurround the brain *o o*, as well as thoſe ſerving for a foundation or prop to the eight legs, *p p*, in the center of which lie the mouth and the beak. From the back part of the brain iſſue two very large nerves, *q q*, which form each of them a remarkable knot, *r r*, after having paſſed through the thorax, and under the muſcles that ſerve to move the acetabula of the common excretory duct. I could count more than twenty little nerves, which ſprung from each ganglion, and were diſtributed to the region of the gills; after running on each ſide of the acetabula, of the common excretory duct, where they in part ſhewed themſelves through the tranſparent ſkin, Tab. LI. Fig. I. *z*.

The genitals of the male Cuttle-Fiſh may be divided into three parts, one teſticle, and two glandulous parts, between which there lies another glandulous body, divided into a great many lobules; and laſtly, a peculiar glandulous and ſpungy body, in ſhape like a heart, ſeated under the animal's ink bag.

That part, which I call the teſticle, on account of its external appearance, is ſo admirably contrived, that it greatly ſurpaſſes all the wonders I have hitherto related of the Cuttle-Fiſh. It ends in a particular open-mouthed tube, which floats looſe in the body, like the end of the ſtraight gut, *u*. It is through this tube the teſticle diſcharges its ſperm, ſo that it may very properly be called the vas deferens of this organ. I could ſometimes obſerve ſome very tender and delicate white fibres hanging from this part, Tab. LII. Fig. V. *a*; but I cannot ſay whether they were natural, or were occaſioned by ſome diſorder in the animal, as I never examined them in a live one. This ſingle teſticle is oval, but it ends at the bottom in a kind of a point, *b*. In the centre of it there is a little body, which very nearly anſwers the paraſtatæ, or corpora variaformia of quadrupedes, and even of man, *c*; but I have not yet been able to diſcover where this veſſel begins or ends. The nearer this little body, juſt taken notice of, approaches the teſticle, the broader it grows: this circumſtance may be beſt ſeen, by turning the teſticle upſide down, and then diveſting it of the great number of membranes which cover it, *e*. I have ſome reaſon to think, that the whole teſticle may be unfolded, and wound into one long veſſel, ſomewhat ſlenderer at its beginning and at its end, than in the middle, and terminating in a curious curled little tube, *d*. The texture of the genital parts already mentioned, is glandulous. In the narrow parts of the channel juſt now ſpoke of, there is found a white ſpermatick matter, which, on wounding this part, iſſues forth in form of coagulated milk; but the ſubſtance contained in the ſomewhat wider parts, is tranſparent: the wideſt parts of all are full of an infinite number of little delicate white parts, ſomewhat crooked, which are altogether free and looſe at their hinder ends, Tab. LII. Fig. VI. *f*; but at their fore ends, they terminate each in a very delicate filament, *g*, by which they are in a manner linked to each other. Theſe delicate fine threads may be unwound, to double the length of the other parts to which they adhere; and on taking both the threads and theſe parts into the open air, the former immediately harden like the threads drawn from ſilk Worms, and ſhine and glitter like a looking glaſs.

The moſt ſurpriſing circumſtance in this part is, that on throwing ſome of theſe into water, they, after a little time, begin to move, and then opening at their hinder, and ſometimes at their fore, extremity, they ſuddenly diſcharge a little white body, which, on its eſcape, rolls and curls itſelf up in a ſerpentine manner, *b*, the larger part, all the while continuing in its former ſtate, without the ſides of it falling together. This ſurpriſing little body, when viewed with the microſcope, looks like a very white Earth-worm, divided into a great many exceeding ſmall rings; and if left in the water for ſome time, it expands and grows bigger by degrees, by the water it imbibes, which makes me imagine, that the water may poſſibly be the cauſe of that wonderful motion obſervable in theſe parts, on their being put into it.

Theſe particles, when thrown into ſpirit of wine, remain perfectly quiet, without any opening.

Theſe parts may be very diſtinctly ſeen thro' the tranſparent coats of the teſticle; and they appear divided into a great many rows. Sometimes even they may be obſerved to have rolled themſelves into ſerpentine coils, and diſcharged their white particles, before the teſticle has been opened, Fig. v. *i i*.

On examining with the microſcope one of theſe minute parts, we may plainly perceive its conſtruction, and can ſee a tranſparent ſpace, like an air bubble, at its hinder end, Fig. vii. *a*. A little higher up is the region, within which lies the little ſurpriſing moving white particle, juſt now ſpoke of, *b*. But I have here repreſented it much ſhorter than it appears through the microſcope, for fear of enlarging the drawing to too great a ſize. This little part grows tranſparent again near its fore end, Fig. VII. *c*. But the fore end itſelf is very neatly curled, *d*, and it is from this extremity that the filament iſſues, which hardens in the air, like the Silkworm's thread, *e e*.

Whether theſe filaments be hollow, and whether the ſperm be generated in the caſes which contain them, as in ſo many kind of ſeminal tubes, or whether all the caſes themſelves, with their contents, be diſcharged by the animal at the time appointed by nature, for its ſhedding its ſperm, are very obſcure queſtions, which as yet I am not able to anſwer *. Let it therefore ſuffice, that I have juſt exhibited, to the glory of the Great Architect, the admirable beauty and con-

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* The public received ſome few years ſince, an account of theſe veſſels in a ſpecies of Cuttle-Fiſh, from the ingenious Mr. Turberville Needham: but we ſee the firſt account of them is owing to this author; and much is yet to be expected in the perfecting their hiſtory, from ſome future philoſopher accuſtomed to theſe inquiries, who ſhall have opportunities of obtaining the animal alive. The ſpecies mentioned by Mr. Needham is, as we have before obſerved, the Loligo of authors; and his obſervations on the conſtruction and action of theſe particular parts, is this——

The outward tranſparent caſe is cartilaginous and elaſtick: its upper extremity is gathered into a round head, which is in reality nothing more than the top of the caſe involuted into itſelf, and by that means cloſing the orifice, through which the interior apparatus ſprings in the time of action.

Within this is contained a tranſparent tube, elaſtick, as it appears from the phenomena, in all directions, and forcing its way whereever it finds a paſſage, which tho' the continuation of it is not equally ſenſible in all parts, may be eaſily diſcovered in a courſe of experiments to inveſt the ſcrew, ſucker, barrel, and that ſpungy ſubſtance, which imbibes the ſemen. The ſcrew is inſerted in the upper part of it, and throws out of the head of it two ſlender ligaments, which faſten it with the whole annexed apparatus to the top of the outward caſe; the ſucker, and barrel or cup, are lodged in the middle of the tube, and the ſpongy ſubſtance containing the ſemen diſtends the lower part.

I ſhall now proceed to the ſeveral phænomena's that appeared in the action of this minute machine, which to me at leaſt ſeemed ſo ſurpriſing and inexplicable, that I think myſelf obliged to premiſe, that I am in no wiſe anſwerable for any ſeeming contradictory conſequences, which may poſſibly be drawn from matters of fact I dont pretend to account for: all I can aſſure the public of, is, that they are literally true, juſt as they are related, and were ſeen by ſeveral perſons, as well as myſelf. The objects I have now by me preſerved in ſpirit of wine, which, though they retained their activity for more than twenty days after they were taken out of the body of the fiſh, and immerſed in ſpirits, without any ſenſible diminution, yet now have in a manner totally loſt it, though they remain to all appearance in the microſcope perfectly the ſame. If therefore any of my readers deſire to verify the facts I have mentioned, they muſt apply in the ſeaſon for freſh objects, and do their utmoſt to procure the milt-veſſels when perfectly ripe for action; for theſe only will anſwer to all the phænomena I have taken notice of, though the leſs mature will ſuffice for moſt of them.

Tho' many of the milt-veſſels, when they are ripe for action, and diſengaged from that glutinous matter which ſurrounds them while they are in the milt-bag, will act immediately in the open air, for which perhaps the ſlighteſt preſſure during extraction may be ſufficient, yet the generality of them will not only bear a tranſlation to the object-plate, and lie quiet for obſervation, but alſo require a drop of water to moiſten the upper extremity of the encloſing caſe, before they begin to operate.

Upon application of this, the extremity begins to evolute and unfold itſelf, and the two ſlender ligaments, which emerge out of the caſe, turn and twiſt themſelves in various directions: at the ſame time the ſcrew moves upwards with a ſlow motion, the ſpires at the top gathering cloſe together, and acting againſt the head of the caſe, while thoſe at the bottom advance proportionably, and ſeem to be continually ſucceeded by others out of the head of the piſton; which ſucceſſion I believe to be apparent only, and not real, the appearance being owing to the nature of the motion in the ſcrew: in the interim, the ſucker and cup, or barrel, move gently on in the ſame direction; and the inferior part of the apparatus, which contains the ſemen, extends itſelf in length proportionably, with a motion at the ſame time upwards, which may be perceived by an increaſe of the vacuity at the bottom of the caſe. Soon after this, the top of the ſcrew, with its encloſing tube, appears out of the head of the caſe, and as it is there faſtened by its ligaments begins to bend: the motion of the whole continues thus ſlow and gradual, till the ſcrew, ſucker, and cup have forced their way, and emerged totally, when at that inſtant the remainder of the apparatus ſprings out at once, the ſucker ſeparates from the cup, the ſeeming ligament below the cup ſwells out to the diameter of the inferior part; the inferior part, though diſtended conſiderably in breadth, more than it had been in the caſe, extends itſelf to five times its original length; two knots, between which the tube contracts itſelf in diameter, form themſelves, each at about the diſtance of one third of the whole from both extremities, and the ſemen flows out of the cup, conſiſting of ſmall opake globules ſwimming in a ſort of ſerous matter, juſt in the ſame form, and without any appearance of life, as I had ſeen it before, when diffuſed at large in the milt-bag. After the operation, it is to be obſerved, that the fringed edges between the two knots appear upon examination to be nothing more than the interior ſpongy ſubſtance broke and disjoined at almoſt equal diſtances, as will be clear from the ſubſequent phænomena.

Sometimes the ſcrew, together with the tube, breaks juſt above the ſucker, and the ſucker remains in the cup, of which I have alſo given a drawing: in that caſe the inveſting tube cloſes inſtantly at the extremity of the ſcrew, as far as it will permit, and contracts itſelf nearly in a cone, which plainly indicates its great elaſticity in this, as its conformation to the ſhape of the encloſed ſubſtance upon the leaſt change does in every other part.

At firſt view, an obſerver would be inclined to think, that the action of the whole machine is to be derived from the ſpring of the ſpiral ſcrew; but the following experiments, which I tried with a view of ſatisfying myſelf in that particular, not only evince the falſehood of that ſuppoſition, by demonſtrating that the ſcrew can at moſt act but as a counter to a force entirely latent, but afford a train of phænomena ſo ſurpriſing, that they totally ſilenced all the hypotheſes I was capable of forming. The experiments were tried upon milt-veſſels, which though not ſufficiently mature for the ejection of the ſucker, dilatation of the ſeeming ligament below the cup, and the expreſſion of the ſemen, had already attained the full force requiſite for the exertion of the interior apparatus out of the encloſing caſe; thus they completely anſwered my preſent purpoſe, as well as the moſt mature could, and remedied the misfortune I had of loſing the only parcel of mature milt-veſſels I have found in the courſe of my inquiry, which I had laid by for further obſervation.

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contrivance of theſe parts; contented as I am in being thought ignorant of every thing elſe belonging to them.

As to the other parts, compoſing in my opinion, the organs of generation, the conſtruction of them is very remarkable; for they ſeem as it were to conſiſt of two diſtinct glands, placed at the ſides of the abdomen, and there connected with the gills, Fig. VIII. *aa*, from which I ſeparated them. Theſe glands are white, and there adheres to each of them another glandulous body, by means of a glandular tube, in form of a ſtalk *bb*. Theſe corpuſcles are of a ſomewhat grayer colour than the reſt, and have each of them a conſiderable ſlit, with a great many little openings at the bottom, through which iſſues the ſeminal matter formed in theſe and the inferior particles.

This ſeminal matter, after flowing from its glands, is conveyed to a bag that lies at one ſide, and is repreſented under the letter *r* of Figure I. Tab. LI. from whence it is diſcharged out of the body by two diſtinct tubes. The mouths of theſe tubes appear very plain at the ſides of the ſtraight gut; and the matter they contain, may even be ſqueezed out of them. Theſe tubes are exhibited in the figure and table laſt mentioned, under the letters *qq*. But I cannot as yet take upon me to ſay whether or no they ought to be called the proſtaſtæ, or what other organs they may properly be.

Among the parts I am deſcribing, there lies a glandulous body divided into lobes Tab. LII. Fig. *cc*, VIII. and connected by means of ſome delicate membranes *dd*. Theſe lobes are again moſt beautifully divided, as it were, into a great many branches, covered with tender, and in ſome ſort membranaceous, glands, which in the animal itſelf forms a moſt entertaining ſpectacle. From this body there ariſes, on preſſing, another kind of ſpermatic matter. The lobes laſt mentioned, and their glands, are of different colours, partly white, and partly inclining to gray; the glandulous body itſelf alſo, which I heretofore repreſented as adhering to the ſtomach, ſeems to have a communication with theſe glands; for as yet I cannot take upon me to affirm poſitively, that it has any. I muſt have more ſubjects to examine, before I can determine any thing in regard to this and ſeveral other particulars relating to this Cuttle-fiſh. The beſt time to take a thorough ſurvey of the creature, would be when the ſperm is not as yet arrived at its full maturity. But ſuch a ſurvey would require a great deal of attention and leiſure.

The third part belonging to the ſpermatic veſſels has been already exhibited, as it appears through the tranſparent ſkin under the letter *t*, in the firſt figure of Tab. LI. Fig. I. It lies in the lower region of the abdomen, under the ink bladder. It is of a glandulous ſpungy ſubſtance, and contains a ſeminal matter, which may be eaſily preſſed out of it. Its ſuperior region is ſomewhat broad, flattiſh, and depreſſed, Tab. LII. Fig. IX. *a*; the inferior terminates in a manner in a double or forked point *b*, ſo as in ſome degree to reſemble the ſhape of a heart. I cannot ſhew the channel by which this part diſcharges its ſpermatic matter, as I tore and broke it, on ſtriving to take it out of the creature's body.

I could not at this time narrowly inſpect the genital organs of the female Cuttle-fiſh, becauſe I wanted a ſufficient number of ſubjects; and thoſe, in which I obſerved all the particulars hitherto related, were both males. For this reaſon I cannot now take upon me to give a ſatisfactory account of the parts viſible in the female, or to ſay whether or no it has any genital organs anſwering to thoſe, I have already deſcribed and delineated, as belonging to the other ſex. I ſhall therefore attempt no more at preſent, than juſt to give a drawing of the genitals of a female Cuttle-fiſh, which I ſome years ago took care to prepare and preſerve, referring to ſome other time, when I ſhall have inclination and leiſure to perform ſuch a taſk, a thorough ſurvey of theſe parts.

The firſt thing I here repreſent, is the ſtraight gut *a*, Tab. LII. Fig. X. to the ſide of which adheres the channel by which the ink is diſcharged *b*. The ink bag itſelf *c*, lies upon the ovary *dd*. At the other ſide of the ſtraight gut

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If the milt-veſſel be divided juſt below the cup, that part which contains the ſemen extends itſelf inſtantly; and though a part only, and not the whole of it ſprings out at the opening, as it does not when ſevered from the reſt of the apparatus, yet upon application of water, it works itſelf out by degrees with a ſlow motion, and emerges almoſt entirely out of its caſe.

If the lower extremity of the outward caſe be cut off, it diſtends the ſeeming ligament below the cup to an inconceivable tenuity, breaks it without deranging the ſcrew, or cauſing any alteration in the ſuperior part of the apparatus, and goes out at the opening.

In one of theſe experiments, the ſeeming ligament breaking after diſtention, ſtruck with ſuch ſmartneſs the ſide of the encloſing caſe, that, though cartilaginous, its extremity forced its way through by its elaſticity, and retired twiſting itſelf again into the caſe; which can be accounted for no other way, than by ſuppoſing it extremely elaſtick, and its force upon this occaſion ſomething analagous to that of a ſilken thread, which, if ſuddenly emitted after diſtention, with a certain direction that it receives from a peculiar ſlight of hand, will open itſelf a paſſage through a ſheet of ſtrong paper.

If the milt-veſſel be divided both above and below the ſemen, it emerges at the two extremities, by extending itſelf in both directions, which being contrary to each other, detain it in the caſe with this additional effect, that it renders the encloſing tube conſpicuous, by ſevering aſunder at ſome of its diviſions the ſpongy ſubſtance which contains the ſemen. I mean by diviſions the rings throughout its whole length, reſembling thoſe of a Worm, though not ſo regular, as they appear through the greateſt magnifier of the common double reflecting microſcopes; yet, with the third magnifier, from which theſe drawings were taken, they are ſeen as exhibited in the figures, like a fringe inveſting the edges. I have ſometimes upon this occaſion counted no leſs than nine ſeparations, though no more than four appear in the drawing; for in this particular, there is no determinate regularity.

If the leaſt orifice be opened with a lancet in the ſide of the outward caſe, it inſtantly conforms itſelf to it, and comes out double.

'Tis obſervable alſo, that the ſcrew, upon ſeparation, ceaſes in every reſpect to operate, and loſes irrecoverably its activity, which is an evident proof, that the whole force of the milt-veſſel is to be derived from the action of the inferior part.

The application of water is for the moſt part neceſſary, and yet the milt-veſſels will often act without it: ſpirit of wine will alſo ſuffice, though the effect is conſiderably ſlower, and the ſpring, with which the inferior part at the cloſe of the operation, when regular, ſuddenly ſtarts out, is totally impeded; but this was underſtood of a ſingle milt-veſſel placed upon the object-plate; for when the whole bag is immerſed in ſpirits, even ſo that the liquid has free acceſs to the whole collection, it cauſes no other alteration, than that the inferior part is ſomewhat extended in length, and recedes ſome little from the bottom of the outward caſe. Oil has no manner of effect in any reſpect whatſoever, though more lubricating than any other liquid.

is an open-mouthed tube or duct *e*, by which the eggs are voided. I here exhibit three of theſe eggs *f*, one half leſs than the natural ſize. Upon the ovary and ink bladder are placed two very beautiful glandulous bodies, repreſented at *gg*; but I cannot now ſay any thing certain concerning them, as moſt of my former obſervations are only recorded by drawings, with a bare explanation. Above theſe two bodies, or rather in the midway between their appendages, appears a remarkable little bladder or bag, which contained a red juice *h*. Laſtly, I exhibit at one ſide all the parts already mentioned, and the gills *i i*, together with their veſſels and diviſions, in their natural ſituation.

I ſhould here finiſh this eſſay, if for order ſake I did not think it proper to add ſomething concerning the Cuttle-fiſh's bone, being the only one to be found in the body of this wonderful animal. The fleſh cloſely ſurrounds this part on every ſide, in the manner obſervable in man and other animals. To obtain a ſatisfactory ſight of it, no more is requiſite than to make an inciſion in the fiſh's back, and ſeparate the bone itſelf from its membranes, and other integuments; all which may be very eaſily performed.

This bone, when newly cut out of the animal, is of a middle nature between a dry and a moiſt ſubſtance; it floats upon the water, if immediately thrown into it. And this, no doubt, is the reaſon of its having been called ſpuma maris, or ſea-froth. Hence alſo it happens, that ſo many of theſe bones are ſeen during the ſummer months floating near our coaſts, upon which they are at laſt thrown, in proportion to the number of Cuttle-fiſhes that have died ſince the preceding ſeaſon. The fiſhermen gather theſe remains, and ſell them to the different tradeſmen, who have occaſion for them. It would take me up a large volume to deſcribe all the wonders obſervable in this bone, in regard to its figure, colour, texture, and other qualities; I ſhall, therefore, only juſt account in a few words for its floating on the ſurface of the water.

This bone which lies in the animal's back, on breaking it, after having firſt cut with a file thro' the hard cruſt that covers it, ſome inches from its fore end, appears to conſiſt of ſeveral teſtaceous plates *a*, Tab. LI. Fig. VI. Of theſe the upper ones are the longeſt, and moſt crooked; and they lie cloſer to each other than the lower ones, which being applied to the hard cruſt of the bone that had been filed off, yield ſomewhat in length to the former. The reaſon why the lower plates ſhould lie looſer, or at a greater diſtance aſunder, than the upper ones, ſeems to be this; that the former have received more nouriſhment during the fiſh's time of growth, than the latter, and therefore increaſed in bulk a great deal faſter. Beſides, the hard cruſt of the bone, by lying nearer the upper plates than the lower ones, is ſufficient to make the former full amends for ſuch a deficiency.

Between theſe plates there are a great many filaments reaching from one plate to the other, like ſo many props or columns, ſo as to hinder the plates from cloſing together. And the great lightneſs of the Cuttle-fiſh's bone, in conſequence of which it cannot but float like a froth upon the water, depends entirely upon this conſtruction.

To make this very conſpicuous, nothing more is neceſſary, than to ſeparate two of theſe plates which lie at the greateſt diſtance aſunder, from the adjacent ones; and this may be very eaſily effected, by breaking with the point of a ſmall pin, the filaments which unite theſe plates together, at the ſame time that they keep them at a proper diſtance aſunder; for their filaments are ſo fine and delicate, that they yield to the leaſt impreſſion.

On viewing with a microſcope the plates prepared in the foregoing manner, the diſpoſition of the columns or props *c*, between the upper and lower plates *de* immediately appears, as likewiſe their figure, and how they conſiſt of a great many very ſmall fibres which are compoſed, as it were of minute globules. We may even obſerve ſome tranſverſe fibres, ſtretching from one column to another, and ſo ſtrengthening them, and connecting them together. Beſides, many of theſe props have a deeper foundation than the reſt; and there is likewiſe a great variety in their figures.

To comprehend thoroughly the conſtruction of theſe parts, and their admirable contrivance, it is proper to take a piece of the bone prepared in the manner juſt now explained, and having faſtened it in a ſafe place, with a little ſtarch paſte, leave it there till it dries. After this, care muſt be taken to ſeparate the upper plate from the props ſupporting it, without doing them any injury, which however difficult, I have often accompliſhed with perfect ſucceſs. By this means it will at length appear, that theſe columns are ſo many hollow ſlender tubes, Tab. LI. Fig. VIII. *g*, naturally full of air, which is a ſufficient reaſon, why the Cuttle-fiſh's bone, when thrown into the water, ſhould always ſwim on its ſurface.

In this ſtate, ſome of the columns appear like perfect tubes, others of a leſs regular form, and many are beautifully bent, like paper folded in a variety of forms. This inflexion is very like that which we obſerve within the noſtrils of hunting hounds, in the bone upon which the ſcent acts; as alſo, in horſes. This conſtruction of the props cannot be perceived with the microſcope, till one of the adjacent plates is removed, otherwiſe they all appear cylindrical, becauſe they are tranſparent. For it is the property of that kind of glaſſes to give almoſt all hollow tranſparent bodies a round appearance.

The ſubſtance forming the cruſt of theſe plates and their props, is in a manner of the nature of an alcaline ſalt; it ferments violently with acids. But on ſeparating from it the membrane, that covers the back part, it appears entirely compoſed of the ſame matter with the plates themſelves, and the interjacent columns, which makes it not improbable, that this ſtony and ſaline bone, found in the back of the Cuttle-fiſh, is originally compoſed of hardened membranes, and this conjecture is confirmed by conſidering attentively that part of the Cuttle-fiſh's bone, which lies within its tail, and the membranes inveſting it; for theſe laſt when examined with the microſcope appear of the ſame conſtruction with the plates and columns themſelves, But it is no eaſy matter to ſeparate theſe membranes; they are ſo firmly connected in that part with the hard cruſt covering the bone. When cautiouſly picked of, they leave a view of the manner in which this animal's bone grows at this place into a ſharp tale Tab. LI. Fig. xi. *b*, which in full grown Cuttle-fiſhes is much longer and more pointed, than in young ones, as in theſe laſt the membranes are not yet hardened. It may therefore be fairly concluded from all the foregoing particulars, conſidered together, that this ſtony bone of the Cuttle-fiſh, is formed in the ſame manner with the bones of men and quadrupedes. Nay, we can very plainly ſee that the blood veſſels not only run over the ſurface of this bone, but penetrate into its ſubſtance.

To cloſe this treatiſe, I muſt offer my moſt humble praiſes to the great Creator, for having made known to us ſo many ſpecimens of His inexhauſtible wiſdom, power, and goodneſs, all the glory of which we ought to give to his Divine Majeſty, praying Him at the ſame time to make us truly obedient to his will: ſo that we may henceforward do nothing but what is agreeable to Him, for in this exact conformity to His pleaſure our preſent and future happineſs entirely conſiſts.

THE END

A treatiſe on the Phyſalus *.

THIS creature, which Rondolet deſcribes from his own obſervations, and from Ælian, is found in the German ſea, and ſometimes is thrown aſhore on its coaſts in the ſummer months. I can produce one of them, which ſtuffed with tow, by a hole made in its back, and afterwards ſowed up, has its ſkin changed to a kind of real leather. I many times this ſummer ſpoke to the fiſhermen to get me one of theſe animals freſh, as they gave me to underſtand they often caught them alive in their nets, but as yet I have not had the good fortune to obtain any of them; I can therefore do no more at preſent than deſcribe it, and illuſtrate my deſcription with figures from ſome ſlight notes and drawings I formerly took of this creature; theſe obſervations, however, may throw great light upon what Rondolet has wrote concerning it, eſpecially what he has affirmed after Ælian of its ſurpriſing inflection. The Phyſalus when turned on its back, Tab. X. Fig. viii. appears ſomewhat broad in the middle, on the forepart toward the head it is a little narrower, and at the tail it ends in a point. The abdomen is full of wrinkles, and is covered with a very delicate kind of biſſus or cottony matter. This creature has on each ſide of its body twenty eight protuberances, called by Rondolet dorſal warts, from which there ſpring very ſtiff briſtles *a a a*. The learned Oligerus Jacobeus, when here in Holland, made me a preſent of a creature of this kind, and called theſe briſtles its legs; but I cannot ſee any reaſon he could have for giving them that name, as the creature cannot uſe them as ſuch, tho' perhaps it may employ them as oars in ſwimming †. The Phyſalus has other protuberances beſides thoſe already mentioned; and except their being ſmaller and ſharper they are of the ſame conſtruction.

In ſome of theſe warts, which I cut from the creatures ſides, Fig. ix. *b*, I could count ſixteen briſtles diſpoſed inwardly into three rows, and united together in each row, by a particular ligament Fig. x. *c*, and all the ſixteen by another common one. The firſt row conſiſted only of two moderately ſtiff but very large briſtles *d*. The ſecond conſiſted of ſix *e*, and the third of eight *f*, differing in length, ſtructure, and firmneſs; all theſe briſtles were of a ſhining black, but there are other ſpecies of this creature, whoſe briſtles are of a bright gold colour. Such are theſe mentioned by Jacobeus in the *Acta Danica Medica*; and I have myſelf ſeen ſome of this kind. There are alſo Phyſali with green briſtles, if we may believe Rondolet, who calls theſe briſtles green hairs. Some of theſe briſtles, which give the creature a reſemblance to the Porcupine or Hedge-hog, appear thro' the miſcroſcope flattiſh and ſharp Fig. xi. *g*, whilſt others appear cylindrick, and ſomewhat thicker about their fore parts, Fig. xii. *h*, where they at laſt terminate in a blunt point.

Under the parts laſt mentioned, there grows on each ſide of the body a prodigious number of delicate gold coloured downy hairs. I have only repreſented thoſe on one ſide Tab. X. Fig. viii. *i i i*, where the briſtles are omitted, to afford a better view of them; theſe delicate hairs ſpring likewiſe from the centers of certain warts, over whoſe ſurface they afterwards ſpread themſelves, Fig. xiii *k*. The laſt warts lie cloſe under the others ſupporting the briſtles, with which the hairy down growing in the form of flocks of wool is naturally intermixed, eſpecially on the upper part of the body, and on the ſides. The opening of the mouth lies forward near the head Fig. VIII. *l*, and over it is a little body reſembling in figure and conſtruction one of the beards that are to be ſeen in ſome fiſhes.

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* This ſingular creature which former naturaliſts have univerſally called Phyſalus, and have been perplexed in what claſs to arrange it, Linnæus refers to his claſs of Worms, Vermes, he arranges it under the ſecond order; the creatures of which he entitles Zoophyta, and to this genus he gives the name of Salacia; by this denomination the creature is known at preſent among naturaliſts, and there is no other known ſpecies of the ſame genus.

† Theſe are not legs, nor intended for its office: they approach more to the nature of arms with hands or fingers; and are properly Tentacula of the creature: their uſe is in finding and ſecuring the creatures prey.

What has been ſaid, is ſufficient to give the reader ſome notion of this inſects conſtruction on its upper part or back, Fig. XIV. where it appears as if entirely compoſed of an aſſemblage of downy hairs and briſtles, the ſurface of this part alſo is rounder, and more convex, and the warts growing on it are ſhorter and ſlenderer than thoſe already ſpoken of, as lying upon the parts, to which the name of feet has been given.

On opening the back of this creature, I found the ſkin in that part lay quite free and looſe over the adjacent fleſh. I likewiſe diſcovered in this place on each ſide of the body, a prodigious number of holes Fig. XV. *a a a a a a*, which by running a probe into them, I found to extend under and between the briſtly tubercles, ſurrounding each ſide of the body, with openings on the outſide, thro' which the creature by an alternate dilatation and contraction of its upper ſkin, takes in the water requiſite to moiſten its gills *b b b b*, which are all the other parts to be ſeen within this hollow of the ſkin, and are conſtructed like the ſcales on the lower part of the bellies of Serpents. As to their texture it is membranaceous, with a ſmooth ſurface; and they are diſpoſed in the moſt beautiful order, for the upper ones, tho' moving freely over the lower, always cover ſome part of them.

If we duly conſider this conſtruction of the body, we cannot be at a loſs to account for the manner in which the Phyſalus, is able to ſwell and bloat itſelf up with air, and afterwards burſt, or as I think I may more properly expreſs myſelf, collapſe into its former ſize and figure; to do all this, it need only firſt dilate the upper portion of its ſkin, that, on its floating to the ſurface, as it muſt neceſſarily do when its bulk is thus increaſed, the air may get into the cavity ſo formed, and then contract the ſame part, ſo as to make it expell the air contained therein; it then falls flat againſt the lower part ſo ſuddenly, as to imitate the noiſe as well as appearance of a real burſting. Hence we may alſo ſee why the Phyſalus, during this laſt operation ſhould appear quite tranſparent, as the ſubtile air impelled at this time under the ſkin, cannot but open an eaſy paſſage thro' it, for the rays of light.

As to the viſcera of this creature, there are many and remarkable ſingularities in them; but as I have yet beſtowed little notice and few deſigns on them, I cannot ſay much of them at preſent. I only remember to have obſerved that the parts about the mouth of the Phyſalus are moveable in the manner of thoſe of the Snails, and are of a pyramidical form, and of a very wonderful contrivance; its heart alſo, and blood-veſſels ſhew themſelves in a very beautiful manner. In the middle of the body I found a part which ſeemed in its upper portion to anſwer the purpoſe of a ſtomach, and towards the tail that of inteſtines. This veſſel was divided into a great many ramifications, which were united, as it were, by mutual anaſtomis's or inoſculations, Tab. X. Fig. XVI. *c*, and were full of, and turgid with, excrements of a kind of earthy clayey colour, divided into little lumps.

As I never ſaw this creature alive, and even dead, only after it had been toſſed about by the waves from one part of the ſhore to another, I can propoſe but few things of it as certain. I don't know whether it is to be accounted venomous, as Rondolet ſeems to entertain that opinion; neither can I take upon me to determine among what ſpecies of animals it is to be claſſed, tho' it ſeems to deſerve a place amongſt Echini, or Sea-Urchins. Rondolet reckons it among his Sea-Caterpillars; but I cannot diſcover in it the leaſt reſemblance to theſe creatures. I ſhall therefore, for the preſent, conclude this hiſtory; but ſhall endeavour to complete it, if an opportunity offers, at ſome other time, when I may have leiſure ſufficient to beſtow on ſo intereſting a ſubject.

The end of the Hiſtory of the Phyſalus.

An epiſtolary diſſertation on the Felix Mas, or Male Fern of Dodoneus.

SIR,

YOU do me no more than juſtice in attributing to me the firſt diſcovery of Fern; for which reaſon I ſhall now lay before you a very curious obſervation on this ſubject, with drawings to illuſtrate it. Were this a proper ſeaſon to obtain one of theſe vegetables freſh and in good order, I ſhould endeavour to ſend you more particulars worthy of your attention; what I now offer being only the reſult of a ſurvey taken of it in a dead and dry condition: I may ſay, however, that it is now ſeveral years ſince, on examining by chance the tubercles growing on the under-ſurface of the Fern-leaves, I diſcovered in them certain little capſules, containing the true ſeed of this plant; tho' many celebrated writers had denied that it had any, whilſt others, who believed the contrary, knew not how to convince the former of their miſtake.

The Male Fern of Dodoneus is a plant too common and well known to require a deſcription; ſo that I ſhall only give a drawing of it, Tab. LIII. Fig. I. *a a*, and the tubercles *b b*, which grow upon its leaves. Theſe tubercles, which the ignorance and negligence of writers had conſidered as little collections of fine duſt and dirt, when carefully viewed, exhibit the moſt wonderful conſtruction that the mind of man can imagine, and ſo eminently diſplay the contrivance, order, providence, and wiſdom of the Great Author of all things, that perhaps a more ſtriking ſpecimen of theſe His adorable perfections is not to be found in any other part of the viſible creation.

Every tubercle conſiſts of certain ſmall leaves, which contain the pods, or true capſules of the ſeeds. At preſent I cannot tell the number of theſe little leaves, as I have none but dry plants by me, in which theſe appear in a diſorderly manner, and curled up like the Fungus we call Jews Ears.

The pods juſt ſpoken of lie within theſe little leaves in the ſame manner as the flowers of the Moly are dipoſed within the globule ſcabbard, or cup which ſurrounds them, before it burſts and expands itſelf into leaves: at this period, theſe flowers reſemble ſo many round balls placed upon ſtalks; and the ſame conſtruction obtains in the pods of the Fernſeeds, which ſtand within the leaves ſurrounding them, each upon its own ſtalk or pedicle, and look in a manner like ſo many ſlender ſtems with large heads.

To give you, Sir, a ſtill better idea of this ſubject, I lay before you a drawing of theſe pods, with their foot-ſtalks, and I ſhall add a deſcription of them. Theſe ſtalks are ſometimes ſingle, Tab. LIII. Fig. II. *c c c*, and ſometimes double, dividing at a little diſtance from their roots *d*; in this caſe each branch carries its own ſeparate pod.

That end of the ſtalk next the pod, is of the moſt ſingular conſtruction that can well be imagined; it there reſembles in that part a furrowed or fluted cord *e e e*, which beautifully encompaſſes the pod in form of a crown, and ſurrounds it like an herbaceous zone; ſo that the two hemiſpheres of the pod ſwell beyond it on each ſide *f f*. The colour of this little cord, when the ſeed is ripe, is of a very pale brown, within the flutings; but the oblong intermediate protuberances are of a ſomewhat deeper brown. There are twelve of theſe protuberances, beſides ſome certain ones, which ſometimes ſpread over the ſurface of the pod itſelf.

The pod is membranaceous, and very delicate *g*; and it is conſtantly of the ſame colour with the ſeed it encloſes. Near the middle of it there is a kind of furrow or ſlit, which divides it into two portions. When the ſeed is full ripe, the pod which till then, was of a tranſparent whiteneſs, turns to a blackiſh brown.

As ſoon therefore as the ſeeds have acquired their perfect degree of maturity, and the little cord is contracted, by drying into the form of an extended line, by a kind of elaſtic power, it endeavours to form a ſtraight line, Tab. LIII. Fig. II. *h h*, and by that means, on a ſudden, very exactly divides the pod into its original, two hemiſpheres *i i i*, ſo as to ſcatter with ſome violenee the encloſed ſeeds into the air. And when this has juſt happened, we may ſee the cavity of the pod divided by little partitions into a number of cells where all the ſeeds have been ſeparately formed.

All theſe particulars, Sir, may be very clearly and diſtinctly ſeen, by examining the ſeeds with a microſcope towards the end of ſummer. In doing this myſelf, I found it neceſſary to bring my head very near them, and I very often had the pleaſure of ſeeing a great number of the pods burſt, and ſcatter their ſeed by the force of the ſurrounding cord, at that time endeavouring to extend itſelf, in conſequence of the contraction or criſpation cauſed in it by the breath from my mouth, and the heat of my body.

As to the ſize of theſe pods, it is a hard matter to give a drawing of them after nature, on account of their extreme minuteneſs, which renders them almoſt imperceptible to the naked eye. Nay, a dot of ſo ſmall extent can ſcarce be made on paper with the fineſt pencil: but the ſeeds themſelves are of ſo amazing a minuteneſs, eſpecially when dry, that the ſharpeſt eyes cannot, unaſſiſted, diſcern them at all. I reckoned above forty-one of theſe ſeeds in one pod, though it had before ſhed a great number.

Who then, Sir, can pretend to ſhew in this ſeed, as may be done in ſome others, the germen or bud, the rind or bark, and leaves of the future plant? No one certainly; here therefore, the Great Creator gives us a complete ſpecimen of His excellent work; to exhibit which properly, is far beyond the reach of the greateſt genius for deſcription and drawing; and it is ſcarce a wonder, that the greateſt naturaliſts were ſo far miſtaken, as to affirm, this plant was quite deſtitute of ſeeds.

I cannot at this time give you a drawing to repreſent the true figure of this ſeed, as what I have by me are dried up, and ſome of them appear larger than others; however, I cannot help letting you have one made as well as I could, from ſuch a dried ſeed in this cloudy winter ſeaſon. Its ſurface is ſomewhat irregular and angular, with certain tubercles on the upper part; which, under the microſcope, appear of a net work form, Tab. LIII. Fig. III. *k*; but it is very difficult to examine theſe ſeeds when expoſed to the air, or turned to the light, becauſe they are of a deep brown colour, as I diſcovered, by endeavouring to view them in the open air, fixed to a hair of my head, which, in compariſon with theſe ſeeds, appeared like the maſt of a firſt rate ſhip.

Neither can I at preſent determine what the number of the pods may be, though I believe every tubercle contains more than ſixty, from whence it would follow, that every tubercle contained at leaſt 2460 ſeeds. The pods, when opened in the middle, plainly ſhew the little ſeeds diſtinctly ſtowed up in them, Fig. II. *l*; and as theſe grains have then acquired the utmoſt degree of maturity, and conſequently lie looſe, they may be eaſily ſhook out of their cells: but this is a ſight we muſt expect to obtain rather by chance, than certainly procure by diſſection; it ſo ſeldom happens, that any attempt to open a pod regularly is attended with ſucceſs. I can at all times ſhew the ſeeds and cords, and every thing beſides, which I have here deſcribed, as I did ſome time ago to Mynheer Arnold Syen, profeſſor of botany, and Doctor Juſtus Schrader of Amſterdam, who both took great pleaſure in contemplating theſe wonders of God in the vegetable kingdom. It is my real opinion, that the Fungi or Muſhrooms, Corals, and other natural productions of that kind, have alſo their ſeed like the Fern, as I ſome time ago endeavoured to demonſtrate in the Coral in particular, in two letters wrote to Monſieur Boccone upon that ſubject.

I cannot, Sir, find words to inform you with what wonderful order, and in how regular a manner, theſe pods burſt under the microſcope; with what force they then ſcatter their ſeeds; or with what a ſurpriſing motion the cords extend themſelves; and with what incomprehenſible wiſdom and contrivance, the ſupreme Architect has ſo diſpoſed every thing, that each part or portion of the burſted pod, ſhould remain fixed to its cord at a particular place. But I hope the drawings I ſend, may be found ſufficient to give you ſome notion of all theſe things.

I have found the ſame conſtruction to obtain in the pods, ſeeds, and cords, of ſeveral different ſpecies of Ferns.: and I make no doubt, but it may be found in the Spleenwort, Hartſtongue, Hermonites, and other plants of that kind.

Hence you may conceive, with what rapidity theſe ſeeds may be wafted about by the wind, ſo as to account for theſe plants being found on the tops of the higheſt trees, and on walls, wherever they can find mould enough to take root in.

The great obſcurity of the human underſtanding, is clearly proved by this obſervation; for was it not very dark indeed, how could it, during ſo many ages, deny that this plant had either ſeed or flowers? inſomuch that it was one of the firſt errors taught young people in books, as well as heard in converſation. We ought therefore to thank the ſun of divine grace, and true fountain of all uſeful knowledge, that we are at laſt ſo happy as to attain more juſt notions of this matter. Should not this miſtake teach us modeſty in our opinions and our judgment upon many other occaſions, ſeeing, upon this, the moſt penetrating geniuſes have all gone aſtray? If we are ſo liable to miſtakes in regard to things that lie open to our inſpection, what are we to ſay of our opinions of things which are inviſible? How many idle notions are formed on ſuch ſubjects? how many ſenſeleſs conceits, with which, however, we ſometimes ſo far ſuffer ourſelves to be deluded, that we make nothing of injuring both in character, and perſon thoſe who happen to be of a contrary opinion? It is therefore abſolutely neceſſary we ſhould always diſtruſt ourſelves, and act with the greateſt circumſpection. In our preſent wretched condition, we are ſurrounded with ignorance on every ſide, and have no other true knowledge than that of our own weakneſs and imperfections. Of ourſelves we can do nothing; all we have, we receive from the gracious hands of the Supreme Being, the munificent rewarder of good actions, of whoſe divine favour, I wiſh you an uninterrupted enjoyment.

A
Short EXPLANATION of the TABLES,
Which are more fully illuſtrated in the
BOOK of NATURE,
OR,
HISTORY of INSECTS.

By J. Swammerdam, M. D.

TAB. I.

Explains the changes of the firſt order or claſs, which are repreſented to the eye, by the aſſiſtance of figures; for which purpoſe the Louſe is exhibited as an example.

N. B. The numeral letters diſtinctly ſhew, after what manner the ſeveral changes ſucceed each other; ſome of the figures are repreſented as they are magnified by the microſcope; the reader muſt obſerve in general, that the ſame method is alſo obſerved in the examples which belong to the ſecond, third, and fourth orders or claſſes of the changes of inſects.

No. I. SHEWS the nit or ſmall egg of a Louſe, delineated in its natural bigneſs, in which the Louſe is contained; being yet clothed in its firſt ſkin or coat. The ſame may be ſeen *fig.* 1. as it is magnified by the microſcope.

No. II. Is the empty ſhell of the egg, or the coat or ſkin of the nit, caſt off by the Louſe; after it has crept out of it.

No. III. Shews the Louſe juſt excluded from its egg, where it plainly appears, how the creature has crept out of the membrane wherewith it was ſurrounded, in a perfect ſtate; and is not obliged to undergo any further change, tho' afterwards it increaſes in bigneſs, and often changes its ſkin. Therefore we have named the Louſe in this ſtate, an oviform-nymph-animal: becauſe it iſſues from its coat or ſkin, perfect in all its limbs.

No. IV. Is repreſented the ſame Louſe ſomewhat bigger, and inveſted as it were in its third or fourth ſkin; which alſo ſoon after is to be caſt off.

No. V. The Louſe, having now attained to the full period of its increaſe, in which ſtate we called it a nymph-animal; from its being then in its laſt ſkin that it ſheds, and indeed we meet with ſome inſects in the firſt claſs, which are alſo ſomewhat changed about the time that they caſt their laſt ſkin, which plainly appears, among other inſtances, in the Longipede, or long-legged Spider, the legs of which increaſe in length when it is caſting its laſt ſkin. After that is caſt, the inſects which belong to this firſt order grow no more, neither are they changed in any reſpect; as may be more plainly underſtood from the figures of the following examples of the four orders, under number V. and VI.

No. VI. The Louſe, having attained its perfect ſtate, and being fully grown, ſo that it is now capable of generation; is repreſented *fig.* III. as magnified by the Microſcope.

FIG. I.

The egg, or nit of the Louſe, as magnified by the Microſcope.

a The oviform border or margin, with which the head of the nit is ſurrounded, within which are viſible certain little cups or uvulæ, of no regular or determinate figure. Theſe cups appear a little bent, and then again ſwell out in the middle, as it were into a whitiſh top. It is obſervable that theſe cups do not wholly fill the internal parts of the border or margin with which the head is ſurrounded.

b b Are two tender ſwellings or extuberances, wherein are placed the eyes of the Louſe; whilſt its limbs yet remain moiſt and ſoft.

Theſe eyes, by imperceptible degrees, grow browner, and appear through the ſkin, and at laſt become entirely black.

c Is a certain white tranſparent part, in the middle of the nit, which we have often ſeen beating regularly in the ſame manner as the heart. This little part is repreſented in *fig.* VI. by letter *b*, and called by us the pancreas, becauſe it moves up and down with the ſtomach.

FIG. II.

The ſhell of the egg, or the empty nit, and the firſt ſkin which the Louſe caſts.

a The border or margin of the head burſt open, with its little cups or uvulæ, and turned back by the Louſe's creeping out at the upper extremity.

b The other part of the empty and caſt ſkin of the nit, from which the border of the head is ſeparated, by which means it has the appearance of a tankard without its cover.

FIG. III.

Shews the Louſe placed on its belly, and magnified by the microſcope.

There appears a ſhining ſkin on its head, with ſome little holes and diviſions. Upon its breaſt or back there is an elegant delineation of a ſhield, which is as it were painted in the middle; and this ſhining ſkin is ornamented with little holes. To the breaſt are fixed the legs, which are full of little ſwellings or extuberances, like thoſe on the ſhagreen ſkin; but they become by degrees imperceptible at the extremity of the legs. By the aſſiſtance of the microſcope it has been diſcovered, that at the margin of the abdomen, the ſkin there appears alſo painted and rough, with little grains like ſhagreen as before deſcribed; but by the help of the beſt microſcope, I have at laſt found that the ſkin is really formed of irregular chequered work, globules, and ſuch like appearances.

N. B. In *fig.* IV, next to be explained, will be pointed out by letters all the remaining parts of the Louſe, one after another.

FIG. IV.

The external and internal tranſparent parts and limbs which are ſeen in the Louſe, as lying on its belly.

a The Aculeus or ſucker.

b b The antennæ or little horns. *c c* The eyes.

d d The ſix legs. *e e e e* The claws.

f The cloven tail, in which the anus is ſeen.

g g The white tranſparent veſſels in the belly and breaſt, which are properly the ramifications of the trachea.

1 2 3 4 *&c.* The ſeven orifices of the pulmonary pipes, on one ſide of the body, which with ſeven others on the oppoſite ſide make together XIV.

h h h The large branches of the aſpera arteria, in their firſt beginning where they open by ſpreading branches into the extremities of the belly, and afterwards communicate together by an anaſtomoſis, or inoſculation.

FIG. V.

The Louſe, lying on its back, delineated according to its natural ſize.

FIG. VI.

The Louſe delineated with the aſſiſtance of the microſcope, in which thoſe parts which could not be ſhewn in fig. IV, *are here repreſented.*

a A brown tranſparent part of the abdomen, which is obſerved to be in continual motion, with its double tranſparent appendages, which are ſtretched far into the breaſt. This brown part with its appendages, is properly the ſtomach; in the middle of them is placed the ſpinal marrow.

b A white ſpot in the middle of the belly, tranſparent, which I imagine to be the pancreas. In a live Louſe it appears to be united with the ſtomach, and, together with it, is moved up and down.

Further, in this Louſe, the articulations of the legs with the breaſt may be plainly ſeen, alſo the bright tranſparent pulmonary pipes, together with the black coloured contents of the ſtomach. At the extremity of the abdomen appear the double claws, like creſcents, which cover the vulva.

FIG. VII.

The branch of the aſpera arteria of the Louſe, conſiderably magnified, yet repreſented in its natural form.

a The rings of the trachea, by which it is always kept open.

b The ſerpentinewindings of thoſe rings.

c The part where thoſe windings appear to be interrupted.

d The part where the rings are largeſt.

e The part where the rings become ſmall again, when the aſpera arteria ſhoots out into another branch.

f A ſmall membrane in the middle of the rings, which properly contains the air.

FIG. VIII.

The ſeven orifices or reſpiratory points of one ſide, ſeparately delineated.

1 2 3 4 5 6 7 Theſe figures ſhew the natural ſituation of the reſpiratory points or orifices

of the aſpera arteria, in one ſide of the human louſe.
a a The reſpiratory points in the belly, which appear with little protuberances like ſmall nipples; beyond the margin of the belly.
b The reſpiratory point in the breaſt.

TAB. II.

FIG. I.

The blood of the Louſe.

a a A ſmall glaſs tube, in which the blood of the louſe aſcends.
b The globules of the blood as they appear through the microſcope.

FIG. II.

The muſcles of the Louſe.

a A broad muſcle. *b* Another narrower.
c A double-bodied muſcle.

FIG. III. IV. and V.

The ſheath or caſe of the aculeus, or ſucker, the aculeus, the throat, the ſtomach, the pancreas, and inteſtines.

a The caſe of the aculeus ſwelled out.
b The aculeus or ſucker.
c The caſe of the aculeus delineated a little larger, and the whole of it repreſented.
d Certain claws which are placed at the end of the caſe of the Aculeus.
e The Aculeus a little bent.
f The gullet beyond the jaws.
g The ſame a little dilated.
h The ſame part where it becomes narrower again, and is joined to the ſtomach.
i i i The ſtomach, which appears to be compoſed of certain globules.
k k The two hidden appendages of the ſtomach.
l l l l The pulmonary pipes of the ſtomach.
m The ſituation of the pancreas.
1 2 3 4 5 Five different delineations of the pancreas.
n The Pylorus. *o o* The ſmall gut.
p p p p The four ſmall guts.
q The inteſtine colon.
r r The dilatation or extenſion of the inteſtines, or Cloaca; where the excrements acquire their figure.
s The ſtraight gut. *t* The anus.
v The part where the blood firſt paſſes through the aculeus into the mouth.
x A remarkable extenſion, occaſioned by the blood's extending the jaws; there it becomes viſible, beyond which the gullet is afterwards ſeen, which conveys the blood into the ſtomach; as has been already ſhewn at letter *f*.

FIG. VI.

The various motions which the ſtomach makes.

1 The ſtomach dilated.
2 The manner in which the ſtomach contracts itſelf.
3 The ſame contractions changed.

FIG. VII.

The ſpinal marrow.

a a a Three knotty dilatations, or ſwellings of the ſpinal marrow.
b b b Six nerves which ariſe from the marrow, and extend to the muſcles of the legs.
c c The nerves which ſpring from the hinder part of the marrow, and are diſtributed through the reſt of the viſcera.
d d The pulmonary pipes in the membrane of the marrow.
e The beginning of the marrow iſſuing from the brain. *f f* The brain.
g g The Dura Mater, with its pulmonary pipes. *h h* The optic nerves. *i i* The eyes.

FIG. VIII.

The ovary of the human Louſe.

a a The vulva, or outward aperture of the ovary, opening into the lower part of the abdomen, cloſed with double plain claws; under which are ſome hairs.
b b b b The five double extremities of the pipes which form the oviduct of the ovary, explained in the figure of one ſide, and are alſo ſhewn in the figure on the other ſide; as they are naturally joined together in one point in the body.
c One of the ten oviducts of the ovary.
d A perfect egg placed in it.
e The rudiments of four eggs.
f f The diviſion of the ovary into common double pipes.
g g The five oviducts of one ſide, nearly repreſented in their natural ſituation.
h The uterus.
i The egg or nit almoſt at its perfection, remaining in the uterus.
k k The ſacculus, or bag which contains a glutinous matter.
l The neck of the uterus.
m The manner by which the eggs are cloſely embraced in the oviduct.
n Certain pulmonary pipes which are ſeen in the oviduct.

FIG. IX. and X.

The ſtructure of the external ſkin, with its various appearances under the microſcope.

a Globular particles viſible in the ſkin.
b b Long channels or pipes.

c Another kind of globular particles is ſeen among the channels or pipes where the ſkin is membranaceous.
d Irregular ſquares in the margin of the ſkin.
e Circular grooves. *f* Globules.
g Globules and grooves.
h h The ſkin marked with points or dots.

The end of the explanation of the figures of the Louſe.

Obſervations on Scorpions, repreſented in Figures.

TAB. III.

FIG. I.

The common Scorpion, and the particular parts of it.

a The head jointed to the breaſt like as in a lobſter, is conſpicuous in the fore-part, in which are two ſmall forceps or pincers, and above are ſeen four eyes; in the middle of the breaſt there are alſo two eyes, there being ſix in all: which may be plainly known to be the number of the eyes.
b b Its eight hairy legs, each divided into ſix joints.
c c Two crooked arms with pincers, each compoſed but of four joints, if you except that by which each arm is joined to the breaſt. Theſe forceps or pincers are ſometimes found broken.
d The ſeven diviſions or rings of the belly.
e The briſtly part, compoſed of ſix joints.
f The aculeus or ſting.

FIG. II.

Another kind of Scorpion.

a a The crooked arms with their forceps, which differ very much from thoſe repreſented at letters *c c*. There are in this Scorpion eight diſtinct eyes, in other reſpects it agrees with the former.

FIG. III.

A large kind of Scorpion brought from the Eaſt-Indies, in which the parts that were deſcribed in the two former are more clearly ſeen, particularly the following.

a The two forceps or pincers placed foremoſt under the head and breaſt.
b Above which there are, on each ſide, ſix eyes, ſome much larger than others: beſides theſe there are, in the middle, as it were above the breaſt, another pair of eyes. There is alſo a remarkable difference in the tail; but I am doubtful whether it was ſo naturally.

FIG. IV.

A ſmaller kind of water Scorpion, which belongs to the ſecond claſs or order of changes, repreſented in its natural ſize.

a The crooked proboſcis.
b b The upper pair of wings.
c c The lower pair of wings.
d d d d The four legs, with two claws at the end of each of them.
e e The arms. *f* The double tail.
g One of its nits or eggs repreſented in its natural ſize.

FIG. V.

The water animalcule in its egg, delineated as it appeared under the microſcope, which in Fig. IV. *letter* g, *was repreſented in its nit of its natural ſize.*

a The head. *b* The eyes. *c c* The legs.
d d The animalcule, with its legs, laid on its back.

FIG. VI.

The parts of generation of the male water ſcorpion.

a The nervous body of the penis cut off.
b The vas differens, as it is elegantly formed by nature.
c Another vas deferens, unfolded.
d The true vaſa deferentia.
e e The teſticles, conſiſting each of five ſmall glands.
f f The veſſels of the teſticles united with the ſmall glands of the teſticles.
g One of theſe veſſels, unfolded.
h h The ſmall ſeminal veſſels.

FIG. VII.

A particular part of one of the oviducts, with its eggs, cut out of the ovary of a female water Scorpion, repreſented as magnified.

a a A particular part of one of the oviducts.
b The briſtly appendages of the firſt and loweſt egg.
c The ſame ſhewn in the ſecond egg.
d The like appearance about the third egg.

FIG. VIII.

The egg ſeperately repreſented, more conſiderably magnified.

a The lower ſmooth and round part of the egg.
b The part where the ſeven briſtly appendages of the egg begin to grow of a red colour.
c Where they change to a white colour.

FIG. IX.

The largeſt kind of water Scorpion.

a Its long and ſlender body.

b b The two ſharp ſmall points to which the two crooked claws of the arms are united.

c c The ſlender legs ſet with rough ſmall hairs.

d The membranous ornaments of the upper wings.

TAB. IV.

This table exhibits the covered or common Snail.

FIG. I.

The Snail with all its parts entire, without its ſhell.

a a The two upper antennæ or horns, with a certain black ſpot; which is the eye.

b b The two lower horns; without eyes.

c The outermoſt lips and the mouth.

d The aperture, through which the parts of generation iſſue; which is very wonderful.

e The border or lip of the ſnail.

f The opening through which the excrements are excluded.

g The aperture through which the Snail breathes.

h h h The extreme fringes of the Snail, which ſerve it inſtead of a foot.

k The ſoft part of the body of the Snail, on which appear the ſame windings as in the ſhell, in which the liver is placed in the largeſt part.

l The tranſparent heart; ſurrounded with dots.

n The Sacculus or alkaline bag ſwelling under the ſkin.

t Tranſparent particles formed like a chain.

FIG. II.

The hard ſkin or ſhell of the Snail.

i The ſhell or habitation of the Snail in which it hides itſelf.

s The inciſions or diviſions on the ſurface of the ſhell.

FIG. III.

The Operculum or Cover.

m The operculum of the ſhell of the ſnail, which ſhuts up the ſhell in the winter, but is again opened in the ſummer.

FIG. IV.

A boiled Snail repreſented of a leſs ſize.

o The alkaline bag ſwelled quite out.

p The extreme convolutions or windings of the liver.

q The border of the Snail contracted.

r The teeth as they appear under the ſkin which is drawn back, and the internal lips.

FIG. V.

A part of the firſt pair of horns, repreſented as magnified.

a The eye in the middle of the extreme point of the horn, placed a little on one ſide.

b The optic nerve.

c The extreme point of the muſcle of the eye.

d An interſection of the eye in the middle, between the muſcle and the nerve; where the eye is firſt drawn in.

e e e Small glandulous grains in the outermoſt ſkin of the horn.

f The inner cavity of the horn, which is ſaid to be poſſeſſed of a muſcle and nerve.

FIG. VI.

The brain, nerves, and muſcles.

1 2 3 4 The four horns inverted.

a a The muſcles of the larger horns.

b b The two ſmall muſcles of the leſſer horns.

c c The four horns of the lips, from which the two little ones ſpring.

d The brain.

e The ſkin drawn off the head, by which the hinder brain is moved when the Snail rolls the ſkin out again.

f The part in which the teeth are fixed, deſcribed by dots, which are of a ſubſtance between horn and bone, and formed like a pear.

g The parts of the jaws, mouth, palate and tongue, which are all moveable, and drawn within the body.

h A particular part of the ſtomach and gullet.

i i The ſalival veſſels.

k k The optic nerves of the upper horns.

l l The membranes which extend, and are fixed to the optic nerves.

m The part of the muſcle in which the optic nerve is inſerted.

n The ſpiral windings of the optic nerve.

o The muſcle, which involves thoſe nerves, open.

p The extreme ſwelling of the optic nerve.

q The eye placed in the extremity of the optic nerve.

r The nerve of the lower horn of one ſide,

s The origin of the nerves of the lower horns.

t Two nerves which are diſpatched to the larger horns.

v The two nerves of the mouth, jaws, and palate.

x Part of a muſcle which draws the nerves of the mouth together with the jaws, tongue, palate, and brain, inward, at once; in a very wonderful manner.

FIG. VII.

The eye, with its particular parts, repreſented as magnified.

a The external figure of the eye.

b b b A muſcle which embraces the optic nerve, unfolded, like a gray-coloured membrane.

c The nerve itſelf, in which the eye is fixed.

d A part of the inverted horn.

e The inverted cavity of the horn.

f The part where the muſcle is faſtened in the nerve.

FIG. VIII.

The three humours of the eye.

a Two needles with which the tunica uvea, lying under the microſcope, is pricked.
b The aqueous humour iſſuing from the wounded eye.
c The vitreous humour flowing out in the ſame manner.
d The cryſtalline humour iſſuing like the others.

TAB. V.

FIG. I.

The open parts of the mouth and jaws.

a The external ſkin in the form of teeth.
b The tooth, placed high in the mouth, cut, with the ſkin, from one ſide, expoſed to view.
c The tooth ſpread out into horny bony points, like needles.
d The ſalival veſſels, with their openings.
e The inner lips, behind which the mouth is folded together.
f A cartilage which covers the tongue, when the Snail ſwallows its food, under which the tongue may be ſheltered in the cavity. All theſe parts are ſhewn, unſeperated, Fig. IV. Letter *r*.

FIG. II.

The Tooth.

a The whole horny bony coalition of the teeth.
b The eight prominent teeth of it.
c The crooked creſcent form of the teeth.

FIG. III.

The tongue, and certain muſcles.

a The tongue, taken out of the mouth.
b The root of the tongue, with its ſituation; the tongue itſelf, as it appears, where all the parts of the jaws and mouth are reclined to the other ſide.
c The two horny bony teeth in the acute extremity of the tongue.
d The three muſcles, which move the parts of the gullet and mouth forward.

FIG. IV.

The heart, its auricle, and the blood and ſalival veſſels.

a The reins, which are viſible in the internal membrane of the border of the Snail, as they are derived from the trunk of the vena cava.
b The aperture of the border.
c The heart with its two valves, and fibrous columns.
d The auricle of the heart.
e The alkaline bag, in its proper place, near the heart.
f The ſtraight gut, near which runs the pipe of the alkaline bag.
g The ſpreading branch of the great artery.
h Certain large branches and ſprigs of the great artery.
i i i i The circumvolution and ſhape of the body repreſented by dots; that the ſituation of theſe parts may be the more exactly demonſtrated. Here may be further obſerved:
n The oblong grooves or channels of the ſtomach.
o o The ſalival veſſels.
p p The trunk from which the ſalival veſſels ſpring.
q A ſmall veſſel which runs over that trunk.
r All the parts of the mouth.

FIG. V.

The alkaline bag.

k That part of the alkaline bag which is connected with the Pericardium.
l The angle where the alkaline bag is connected with the inteſtine and liver.
m Another part of the alkaline bag adjacent to its own pipe, and of a wateriſh colour.
N. B. We have joined in one Table the Fig. IV. and V. the explanations of which are here ſeperated, becauſe though we found, in the author's manuſcript, the explanation of Fig. V. by itſelf, yet we could not meet with the figure itſelf apart in the Table; but that does not ſignify, as it may be underſtood by the fourth figure.

FIG. VI.

The ſtomach, inteſtines, and liver.

a The extreme winding of the liver.
b b b The lobes of the liver, where it appears at once, after what manner the inteſtines are wound about; a certain part of it, with the ſtomach, is repreſented out of its place.
c The ſtomach. *d* The Pylorus.
e The ſtraight gut.
f The paſſage of the inteſtine into the border.
g The part where the biliary ducts empty themſelves into the inteſtine.

FIG. VII.

The ſame parts repreſented, as reviewed from the other ſide.

a The liver. *b* The inteſtines.
c The ſtraight gut. *d* The ſtomach

FIG. VIII.

The biliary ducts.

a The naked biliary ducts, with a ſmall part of the liver.

b The ſtomach. *c* The ſmall guts.
d The ſtraight gut.

FIG. IX.

The veſſels of the liver.

a Several veſſels of the liver ſeparately repreſented.

FIG. X.

The genital parts of the male and female,

a The penis.
b b The length of the penis, and the extreme point of it.
c c c The uterus. *d d* The ovary.
e The teſticles, which are ſmall filaments that ſpring from two trunks.
f The hidden appendage of the uterus.
g The common duct between the penis and uterus.
h h The oblong vas deferentia.
i Its ſmall tube, which opens itſelf into the uterus.
k The pear-ſhaped little ball, in which the purple Snail keeps its purple liquid.
l A little part twiſted like a chain.
m Its duct, or little pipe.
n n n The ligament of the uterus.
o The muſcle which leads the penis outward.
p The muſcle which draws the penis inward.
q The nerve of the penis,
r The mouth of the vulva.
s The broad muſcle of the uterus.
t The ſlender muſcle of the uterus.
v The nerve of the uterus.
z The extremity of the chain-like little part.

FIG. XI.

The teſticles.

x The little tubes of the teſticles, conſiſting of filaments, of which ſixty-ſix are reckoned.

FIG. XII and XIII

The blind appendage of the uterus opened, with the ſaline bony contents.

y The blind appendage of the uterus divided in the middle, between which the ſaline bony part, which readily ferments in aqua fortis, is ſeen.
a The root of the ſaline bony part, by which it is joined to the muſcular and nervous pear-ſhaped globule.
b The fine ſmooth part of it, which is all hollow; and by degrees becomes more ſlender and acute.
c The pear-ſhaped globule, to which the ſaline bony part is fixed.

N. B. Here again we have marked a ſingle figure with a double number, becauſe we could only find, in the Tables, the XIIth figure, although in the body of the work, and in the ſhort explanations of the tables, we find the XIIIth quoted: but this is of ſmall importance, as the figure which we have given contains all the particulars that we want.

FIG. XIV.

A particular ſmall ſtony, or ſaline bony part, as ſeen by the microſcope.

d d d d The four margins, or ſurrounding backs.
e The cavity ſtretched out in the middle of the boney part.

FIG. XV.

The chain-like part.

a The extremity of the chain-like part unfolded, in order to ſhew its conſtruction.

FIG. XVI.

The uterus.

r Exhibits the cavities of the uterus blown up, in order to ſhew how the diviſions of it are formed.

FIG. XVII.

a Here are ſeen in the neck of the amorous Snail, the external opening of the vulva, or genital parts, which with the part under the penis, and the appendage of the uterus, together with all the ſpermatic veſſels have been already repreſented in *fig.* X. let. *r.*

FIG. XVIII.

The penis and uterus themſelves turned out and erected.

b The penis and uterus turned out and erected, and ſtretched out beyond the neck.
i i The two upper horns.
k One of the lower horns, which is then a little removed from its place.

FIG. XIX.

The penis, and internal orifice of the womb.

c The penis only, not wholly, turned out of its cavity, and erected.
d The internal orifice of the womb alſo a little turned out, and extended out of the neck.
l The lower horn removed from its place, toward the horn of the other ſide.

FIG. XX.

Of their copulation.

e The penis of one of the Snails rolled out.
f The apperture of the uterus of the other Snail, admitting the penis of the former.

g The aperture of the uterus of the firſt Snail, which in like manner admits the penis of the other Snail *h*.

TAB. VI.

The brain and nerves.

a All the parts of mouth, jaws and palate.
b The gullet cut off. *c* The brain.
d d The beginning of the ſpinal marrow, divided into two ſtrong nerves.
e The knot or ſwelling formed by the nerves.
f The muſcle by which the knot, or ſwelling of the ſpinal marrow is inwardly moved.
g The two parts of the muſcles, which belong to the inward lips of the mouth, which are inſerted by ſome tendons in the knot or ſwelling of the ſpinal marrow, and which, together with the nerves, the muſcles draw within the body.
h h A pair of nerves which are ſeen in the mouth, jaws and palate.
i i A pair of optic nerves.
k k A pair of nerves which reach to the roots of the horns and to the ſkin.
l l. The nerves of the lower horns which ariſe from the former pair.
m m Two tender nerves, which reach to the muſcles of the ſkin and head, cut off.
n n A pair of nerves ſituated under the parts of the mouth.
o o Other pairs of nerves which are diſpatched to the muſcles of the neck.
p A nerve which reaches to the ſpermatic veſſels, to which alſo a ſmall part of the penis adheres.
q The nerves which are diſtributed thro' the membranes of the neck.
r r The nerves which are diſpatched to the muſcles at the ſides of the body.
s A nerve and muſcle which reach to the uterus.
t A nerve of the verge ſtretched inward to the right ſide.
v A like nerve on the left ſide.
x The nerves fixed in the tendons of the two ſtrong muſcles, which move the middle of the body. See *fig.* 11. *n n* of this Table.
y y y The nerves which reach to the verge of the foot of the body.
z Some of theſe nerves cut off from the right ſide are omitted, to avoid confuſion.

FIG. II.

The muſcles of the Snail.

a The part of the ſtony bone or ſhell of the Snail, where the muſcles are inſerted.
b b The inſertion of the two ſtrongeſt muſcles of the Snail, by the aſſiſtance of which it creeps and moves.
c The part where theſe muſcles ſtretch the tail itſelf backward or inward, and which paſs under the pillar of the ſhell.
d. The part where the muſcles of the verge are inſerted.
e The muſcles which draw in all the parts of the mouth, jaws and palate.
f The acute extremity of the tongue.
g The baſis or root of the tongue.
h h The muſcles of the eyes.
i i The curled foldings of the nerves among thoſe muſcles.
k k A part left of the firſt pair of horns, ſtill adhering to the muſcles.
l l A pair of muſcles which draw the lips and the knot or ſwelling of the ſpinal marrow inward.
m m The muſcles of the lower horns, which ariſe from the former pair.
n n Two ſtrong muſcles which draw the middle of the body into the ſhell.
o The part where they are inſerted.
p p The internal ſurface of the ſhell, in which its ſpiral windings, cells, and circumvolutions are ſeen.
q q q q q The fringe or border, or foot of the Snail.
r The cavity of the pillar.

FIG. III.

The convolutions, or windings of the ſhell.

a The outward opening of the ſhell at which the Snail creeps out, and the winding which forms the firſt cell or inward diviſion.
b The ſecond diviſion. *c* The third.
d The fourth. *e* The fifth and laſt.

FIG. IV.

The internal part of the ſhell broke open.

1 2 3 4 5 Are ſeen the inward windings of the ſhell, when all the partitions are broke open.

FIG. V.

The Pillar.

a The upper aperture and windings of the pillar.
b The lower aperture of the pillar, which may be ſeen more plainly in *fig.* 11. *r.*

FIG. VI.

The Pillar.

c The aperture, the ſpiral windings, and the conſtruction of the pillar diſtinctly repreſented.

FIG. VII.

Shews in what manner the greater or leſs diviſions of the ſhell may be formed, as it is broken off from the pillar and its partitions.

d A part of the ſhell broken off, almoſt to the end of its ſpiral winding.
e f Two others, leſs broken

TAB. VII.

FIG. I.

The Turbo or Verticillum.

a The beginning of the windings of the Turbo.
b The end of thoſe windings.

FIG. III.

The voluta, or the cylinder or pyramidal Snail,

a The opening or entrance of it.
b Where it becomes narrower.
c Another convolution or winding.
d The pillar and the other internal ſpiral windings of it.

FIG. III.

The Concha Veneris.

a The entrance divided into little teeth.
b The windings round the pillar.

FIG. IV.

The pencil Snail.

a The outward entrance of it.
b Another of its winding diviſions.
c The third. *d* The fourth. *e* The fifth.
f The ſixth. *g* The ſeventh.

FIG. V.

The tubular Snail.

a The beginning like a plain tube or inteſtine.
b. Its ſpiral windings and convolutions.

FIG. VI.

The tubular Snail.

c c The cavities which the tubular Snail forms, when the partitions of it are gradually convolved together, and applied one to another. But if their cavities are joined to others, the cavity of the pillar is thereby formed. See *Tab.* VI. *Fig.* II. *r.*

FIG. VII.

A Snail like the Cornu Ammonis.

a The hollow perforated partition in the beginning of the Snail,
1 2 3 4 5 *&c.* The diviſions of the Snail, which are formed by the various number of the partitions.

FIG. VIII.

The partitions, with the naked ſurrounding ſhell,

b b Six partitions, from which the outward ſhell is removed.
c The part where the little tubes of the partitions are mutually received.

FIG. IX.

A partition, with its little tube repreſented of a large ſize.

d d d The extreme compaſs of the partition.
e The aperture of the partition which leads to the little tube.
f The perforated handle, or little tube of the partition.

FIG. X.

Three partitions of different ſizes, which mutually receive each other,

g The little tube of the firſt partition, fixed into the little tube of the ſecond partition.
h The little tube of the ſecond partition, fixed in the tube of the third partition.
i i i The partitions, with their little tubes gradually decreaſing in ſize.

FIG. XI.

The oval Turbo, with its windings turned contrary to thoſe in other Snails.

a The entrance opening into the oppoſite ſide, and obliquely winding aſcends towards the left.

TAB. VIII.

FIG. I.

The little Turbo.

a The ſhell of this Snail, with its windings turned the contrary way.
b Part of the body of the Snail creeping out of the ſhell.
c c Its two larger horns, in which the eyes are placed.

FIG. II.

The ſhell of the Snail repreſented, and of an enlarged ſize.

a The entrance extended to the oppoſite ſide.
b The aperture of the pillar.
c c c The ridges, or ribs of the ſurface.

FIG. III.

The ſhell of the ſmall Snail, found under the barks of the Willow.

a The ſhell of the ſmall Snail; a little flatted.

FIG. IV.

The ſmall water oval Snail.

a The oval channelled ſhell of the Snail.
b The hinder part of the ſhell convolved into a double ſpiral winding.

c The body of the Snail which creeps out from thence, marked with black points or ſpots.

d The two obtuſe horns, in which the eyes are are placed, alſo the upper, lower, and ſmaller horns.

F I G. V.

The garden Snail.

a The aperture of the genital parts, placed a little lower in the neck than in the common Snail.

b b The uterus.

c c The ligament of the uterus.

d The bag which holds the glutinous moiſture.

e The chain-like little part.

f The little legs in the ovary.

g The extreme ſpiral part of the liver.

h The purple little knot.

i The other ſmall tube of the purple little part.

k The connexion of the purple little knot with the uterus.

l The blind appendage of the uterus.

m The teſticles

n The alkaline little bone. *o o* The penis.

p The muſcle which draws the penis.

q The common duct between the penis and uterus.

r The acute end of the penis, curled into various windings.

F I G. VI.

Two garden Snails, in the act of coition.

a The penis of each wonderfully twiſted together.

b The penis of one of the Snails inſinuating itſelf into the

c Uterus of the other.

d The penis of the other Snail, in like manner, inſinuating itſelf into the

e Uterus of the former Snail.

f The aperture and diviſions of the verge, as ſeen in this Snail, at this time.

g At the ſame time nothing is ſeen of the verge in the other Snail.

F I G. VII.

The naked houſe Snail.

a The upper horns, which have eyes.

b b The lower horns, which are much ſmaller.

c c The velabrum, or eminence which is fixed to the body.

d The aperture in the neck, through which the genitals are extended.

e The aperture of the velabrum, by which the Snail breathes.

f The prominent part of the tail, like a cock's comb.

F I G. VIII.

The Snail ſtone.

a The hollow like Snail ſtone.

b The ſurface of it, interwoven as it were with veſſels.

F I G. IX.

The genital parts of the houſe Snail.

a The three apertures of the genitals, in the neck, which unite in one paſſage on the outſide.

b b The penis. *c c c c* The uterus.

d The purple bag

e A ſmall filament, which reaches from the penis to the ligament of the uterus.

f f f The ligament of the uterus.

g g The ſmall eggs ſticking in the womb.

h h A bag, containing a glutinous matter.

i i A chain-like little part.

k The ovary.

T A B. IX.

F I G. I.

The field or path-way Snail.

a Its larger horns.

b The aperture of the velabrum, or the eminence, by which it breathes, and diſcharges its excrements.

c c Glandulous triangular protuberances, which riſe obliquely from the body.

d d The gloſſy red verge which ſurrounds the body.

F I G. II.

The internal parts of the field or path-way Snail.

a The mouth and palate.

b b The larger horns drawn in.

c The ſkin of the head divided.

d The gullet. *e* The brain.

f The beginning of the ſtomach.

g g The ſalival veſſels.

h h The glandular corpuſcles, from which the ſalival veſſels ariſe.

i The ſtomach covered with veſſels.

k k The inteſtines. *l l l* The liver.

m The large gall-bag, which diſcharges itſelf into the inteſtines.

n The aperture of the genitals in the neck.

o The penis.

p The little tube which opens from the penis, into the uterus.

q The purple bag.

r The little tube of the purple bag, which is inſerted in the penis.

s The ſtrong and thick origin of the uterus.

t The ſlenderer part of the origin of the uterus.

u u u u The uterus itſelf.

x x x Whitiſh veſſels, which connect the uterus and its ligaments.

y y The glutinous bag.

z The chain-like little tube.

α The ſmall gut. *β* The ovary.

γ The heart in its place. *δ δ* The alkaline bag.

F I G.

FIG. III.

The ovary of the field or path-way Snail.

a The ovary large and expanded, as it appeared ſome months after coition.
b b The little eggs, viſible in the ovary.
c The chain-like little part.

FIG. IV.

The common water Snail.

a Its turbinated ſhell.
b b The eyes placed at the bottom or root of the horns.
c c The horns, which terminate in ſharp points.
d The aperture of the verge.
e The aperture through which the penis comes out.
f The opening of the uterus.
g g The verge fitted to the internal ſurface round the ſhell.
h The tooth.
i i The body, by which the Snail creeps and ſwims.

FIG. V.

The internal parts of the wonderous viviparous Snail.

a The Snail taken out of the ſhell.
b The head. *c c* The horns.
d d The eyes. *e* The vulva. *f* The gills.
g The verge.
h The windings of the body.
i i i The part which ſerves as a foot.
k The cover of the ſhell, which is placed on the foot.

FIG. VI.

The internal parts.

a a The cover of the Snail preſſed cloſe againſt the fore parts of the body.
b The horns and mouth contracted.
c The Vulva.
d The fringe or margin, beautifully folded.
e The end of the ſtraight gut.
f The gills.
g The uterus, open; containing the living fetus.

FIG. VII.

The little Worm found alive in the wonderous viviparous Snail.

a The oblong figure of the Worm.
b The oblong tranſparent furrows or ridges which appear in the body of the Worm.

FIG. VIII.

Two ſmaller Worms, which iſſued out of one of the Worms in diſſecting.

a Its thick head. *b* The ſlender tail.

FIG. IX.

A ſmall live Snail, found in the uterus of the wonderful viviparous Snail.

a The ſize of that ſmall Snail, equal to that of a common pea.

FIG. X.

The ſhell of that ſmall Snail, as magnified.

b The beautiful conſtruction of the ſhell.
c c c c c c c Seven rows of briſtly hairs, with which it is ſurrounded.

FIG. XI.

Perfect eggs found in the uterus of a viviparous Snail.

a a a The little navel-ſtring by which they are fixed to the uterus.
b b The double navel-ſtring of one of the eggs.
c c c A ſmall Snail, ſticking in an egg.
d d The ſame taken out of its egg.
e A Snail, ſticking in its egg, which fell to the bottom, when the ſhell was ſuſpended by its ſtring.

FIG. XII.

A ſmall Snail taken out of its egg, and magninified by the microſcope.

a a Its eyes, black like pitch.
b The horns. *c* The mouth.
d The reſt of the body.
e The operculum, or cover annexed to the tail.
f The ſhell of the ſnail.

FIG. XIII.

The ſhell of the viviparous Snail, repreſented in its natural ſize, cleared of its foulneſs and perioſteum; in order to ſhew, the more diſtinctly, its form and conſtruction.

FIG. XIV.

The ſea Snail, called by the Hollanders Aliekruyk; they are found among muſcles.

a The Snail itſelf, with its little horns, eyes, and foot.
b The part where the ſhell of this Snail is of a globular form.
c Prominent hollows or channels on the ſurface of the ſhell.
1 2 3 4 5 The windings of the ſhell.

FIG. XV.

Another ſpecies of the Snail, called Aliekruyk, commonly ſold in Amſterdam.

d A kind of wreaths, which ſurround the ſhell, adorned with a colour like that of muſk, in the interſtices of which the ſhell appears green.

e Five oblong, crooked, hollow openings; eaten through by worms.

FIG. XVI.

One of thoſe worms which eat through the ſhells of the Snails, repreſented of its natural ſize.

FIG. XVII.

The ſame Worm, repreſented as magnified.

a The head. *b* The tail.
c c Many ſmall hairs on each ſide of the body.

FIG. XVIII.

The Snail, called Aliekruyk, repreſented as magnified.

a The head and mouth. *b b* The horns.
c c The eyes. *d d* The foot or verge.
e The cover of the Snail, of which only a ſmall part is ſeen.
f The ſhell very large, with its wreaths worn out.

FIG. XIX.

The cover of the Snail, repreſented as magnified.

g The cover, whoſe convolutions are formed like the windings of the ſhell.

FIG. XX.

The tongue of the Snail, called Aliekruyk, of its natural ſize.

h The fore part of the tongue, ſituated in the mouth.
i The part of the tongue placed within the body, beautifully folded in ſerpentine windings.

TAB. X.

FIG. I.

The ſmall water Turbo.

a The ſhell of the ſmall water Turbo, which is formed very like the viviparous Snail.

FIG. II.

The umbilicated marble water Snail.

a The fore part, formed like an umbilicus, or navel.
b The oval broader part.

FIG. III.

The flattened water Snail.

a a The two lips. *b b* The verge or foot.
c c The black eyes. *d d* The horns.
e The long ſlender body.
f The air hole in the verge.
g The aperture of the genitals.
h h The ſhell of the Snail flat on the left aſide.

FIG. IV.

The other ſide of the ſhell, of the ſame Snail, repreſented.

a The right ſide of the ſhell, which is concave, and, ſinking in the middle, is rolled into itſelf.

FIG. V.

The ſmall flattened Snail.

a A ſmall margin, which ſnrrounds the ſhell.

FIG. VI.

The freſh water Muſcle, found in the rivers in Holland.

a a The lips or verge which ſurround the whole body.
b b The papillæ, or nipples of the muſcle.
c c c c The four large gills.
d d d d The four ſmall gills.
e The hard part of the body.
f The ſoft part of the body.

FIG. VII.

The inſide of the ſhell of the Muſcle repreſented.

a The part, in the acute extremity of the ſhell, where the muſcle is faſtened.
b The part in the thick or broad extremity of the ſhell where the muſcle is faſtened: where are viſible four ſmall holes.
c c c The part where the mouth of the muſcle is faſtened.
d The ſpiral winding of the ſhell.
e e The two eminences, by the help of which both valves are ſtrongly joined together, as by ginglymus.

FIG. VIII.

The Phyſalus laid on its back, in order to exhibit the wrinkles on its belly.

a a a Twenty-eight of the greater, and ſome of the leſſer external, parts, extant on each ſide of the body, and from which there ſpring black ſtiff briſtles, of which there is but one ſide to be ſeen in this place.
i i i Some woolly hairs like down, of a gold colour, and placed under the parts, containing the lateral briſtles. But I have here omitted theſe briſtles, in order to render the hair itſelf more conſpicuous.
l The opening of the mouth, above which appears a kind of beard, like that of bearded fiſhes.

FIG. IX.

One of the above eight and twenty greater external parts, ſeperated from the body, and exhibited by itſelf, with its black briſtles.

b An Articulus, or joint, repreſented by itſelf, and ſhewing in what manner the briſtles grow from under it.

FIG.

FIG. X.

The ſaid briſtles, repreſented in three orders, as they appear when plucked from the parts producing them.

- *c* The ligament that connects the briſtles, and afterwards appears about all the other briſtles.
- *d* Two of the largeſt and ſtiffeſt briſtles with their ligament, which is placed almoſt in the middle of them.
- *e* Six briſtles with their ligaments ſome of which are more fine and delicate than others.
- *f* Eight briſtles with their ligament, differing in ſtructure, length and ſtiffneſs.

FIG. XI.

One of the ſaid briſtles ſeen through a microſcope.

- *g* A flattiſh briſtle ending in a point.

FIG. XII.

Another briſtle viewed likewiſe through the microſcope.

- *h* A long round ſmooth briſtle, ſomewhat more ſwollen on the forepart, but afterwards terminating in an obtuſe point.

FIG. XIII.

Some hairs of a golden colour, with their roots.

- *k* Some very fine hairs, like down, ſpringing alſo from one centre or ſpot like the briſtles.

FIG. XIV.

The ſloping region of the back, covered with briſtles and delicate hairs, and moreover of a ſomewhat convex form.

FIG. XV.

The back of the Phyſalus laid open.

- *a a a a a a* The natural openings on each ſide of the body, thro' which the water flows to and from the gills.
- *b b b b* The membranaceous gills which move freely one over another, like the larger ſcales in fiſh.

FIG. XVI.

The inteſtines of the Phyſalus rudely delineated.

- *a* The ſtructure of the inteſtines, which look as if they communicated with one another.

TAB. XI.

FIG. I.

The Cancellus, with its bony or ſhelly ſkin

- *a* The ſhell, or true ſkin of the cancellus.
- *b* The five ſpiral windings of the ſhell.
- *c* Two eyes, below which are ſome briſtly articulated hairs.
- *d d* Two horns.
- *e* The right arm, and its forceps, which is the largeſt.
- *f* The left arm, which is the leaſt.
- *g g* The four foremoſt legs.

FIG. II.

The Cancellus, out of its ſkin or ſhell, lying on its back.

- *a a* The eyes, between which are ſeen four briſtly articulated hairs.
- *b b* The horns. *c* The left and leaſt arm.
- *d* The right and largeſt arm.
- *e* The two firſt pair of legs.
- *f f* The third pair of legs, which has ſmall forceps.
- *g g* The fourth pair of legs, which are worthy of notice, becauſe perforated by a double little tube of the genitals, to which it yields a paſſage.
- *h h* Three articulated briſtly hairs, to which the eggs are ſtrongly fixed.
- *i* The tendinous point of the muſcles, or the part in which the tendons of the muſcles meet, and where the Cancellus is faſtened in his ſhell, that it can never go entirely out of it.
- *k* The tail, with its particular part.

FIG. III. IV. and V.

The tail, the ſtraight and cloſed guts, and appendages of the Cancellus, repreſented a little larger than they naturally are.

- *a* The tail, conſiſting of two teſtaceous articulations.
- *b* The verge of the anus, which being bent inwardly may be hid under the tail.
- *c* The ſtraight gut.
- *d d* Three little teſtaceous bones on each ſide of the tail, which are articulated among themſelves and with the bone.
- *e* A ſmall part of the inteſtine.
- *f* The blind or cloſed gut, or what is anologous to it.
- *g g* The appendages, which in the living creature are ſeen beautifully through it.
- *h h* The origin of the appendages, which ſpring from two diſtinct ducts.
- *i i* The appendages, whoſe ſituation was ſhewn at letter *g g*, are ſeen here ſeparated.

FIG. VI.

One of the pair of legs ſeparate from the reſt, repreſented magnified, together with the genital veſſel, entire, by which that leg is on one ſide, perforated.

- 1 2 3 4 5 The five articulations of the fourth pair of legs.
- *a a* The winding of the genital veſſel.
- *b b* Its ſpiral windings which terminate in one narrow tube.

c The extremity of its end.
d The part in which the genital veſſel, after a wonderful manner, perforates the fourth pair of legs throughout the fifth articulation.

FIG. VII. and VIII.

The heart and one of the gills, repreſented as magnified.

a a The heart. *b* Four veſſels iſſuing from the upper part of the heart.
c Two other veſſels iſſuing from the lower part of the heart.
d Some blood veſſels diſcharged of their fleſh, and rolled out.
e One of the XXII gills.
f The thick and broad part of it
g The acute extremity.
h The diviſion of the gills.

N. B. *Thoſe white hollows or grooves, which run longitudinally through the middle of the gill, ſhew the cartilages, near which the blood veſſels are conveyed; in which part they appear thicker and whiter.*

FIG. IX. X. and XI.

The brain, ſpiral marrow, eyes, cornea, and inverted pyramidal fibres, repreſented as magnified, beyond their natural ſize.

a a The brain.
b b The optic nerves, one of which is laid entirely bare.
c The origin of the ſpiral marrow, which is ſeparated, and affords in the living inſect a paſſage for the gullet to the ſtomach.
d The firſt knot or ſwelling, with the nerves it emits.
e e e e e The remaining five knots of the marrow.
f f Nerves which ſpring from the marrow.
g Theſe nerves elegantly decuſſate one over the other, iſſuing from the right to the left, and from the left to the right ſide·
h Part of the cruſt as yet ſticking to the eye, near which the naked nerve is viſible.
i The cornea tunica, and the manner by which the annular cruſt like a tooth inſinuates itſelf into it.
k A gelatinous hexagonal matter placed within the eye, above the inverted pyramidal fibres, which appears on removing of the cornea.
l The inverted pyramidal fibres and their ſituation.
m The black part of thoſe fibres, which ſpring from the tunica uvea.
n The lower part of the fibres which appears brown.
o The middle part of them which is limped.
p p A certain part of thoſe fibres, enlarged by the microſcope, by which it appears, that each of theſe fibres conſiſts of many other ſmall fibres, all which are again compoſed of regular globules.

TAB. XII.

No. I. The vermicle or worm of the Libella or Dragon-fly, ſticking as yet in its firſt ſkin, when it is called an egg: repreſented magnified by the microſcope.
II. The egg itſelf, deſerted by the worm, repreſented of its natural ſize.
III. The worm, as come out of the egg, called, by this author, an Oviform Nymph-vermicle.
IV. The ſame worm a little more grown, when the follicles, or membranaceous bags of the four wings are obſerved to ſpring.
V. The ſame worm, perfect, with its four follicles or little bags, increaſed to their due ſize, called in this ſtate the Nymph-Vermicle.
VI. The Libella or Dragon-fly in its perfect ſtate, having attained its full age, and fit for generation.

FIG. I.

The egg of the Dragon-fly, as magnified by the microſcope.

FIG. II.

The Nymph-Vermicle of the Dragon-fly, caſting its ſkin.

a a The feet fixed with the claws.
b The head and eyes burſt forth.
c c The ſix legs, now cleared from their ſkins.
d d The wings, as yet folded up.

FIG. III.

Of the copulation of the Dragon-flies.

a the tail of the male.
b The female receiving into her neck the tail of the male, and embracing it with her legs.
c The tail of the female turned toward the breaſt of the male.

FIG. IV.

The nymph of the largeſt Dragon-fly.

a a The eyes. *b b* The horns. *c* The teeth.
d d The legs armed with ſharp claws.
e e The little bags, or caſes of the wings.
f f The diviſions of the abdomen,
g The ſtings, or prickles of the tail.

FIG. V.

The Nymph-Vermicle of the middle ſized Dragon-fly.

a The lips and teeth. *b* The hairy legs.
c The little bags, or caſes of the wings.
d The ſtings, or plickles of the tail.

FIG. VI.

FIG. VI.

The Nymph-Vermicle of a ſingular kind of a Dragon-fly.

a The horns. *b b* Six long legs.
c The little bags, or caſes of the wings.
d The hairy belly.
e The triangular appendages of the belly.

FIG. VII.

The Nymph-Vermicle of the ſmalleſt Dragon-fly, found common in Holland.

TAB. XIII.

FIG. I.

The Worm of the Ephemerus, of the firſt year's growth, three quarters of a Dutch inch long, in which is not the leaſt appearance of wings; but the five gills are viſible on the back, from whence come in ſight the ten lower rowing fins.

FIG. II.

The Worm of the Ephemerus of the ſecond year's growth, five thirds of an inch long; the little bags or caſes in which the wings are encloſed.

FIG. III.

The Worm of the Ephemerus of the third year's growth, a female, about two inches and a half long; provided with the little bags or caſes of the wings, which are now viſible.

FIG. IV.

The largeſt Worm of the Ephemerus, in which all the parts elegantly and diſtinctly appear,

a The eyes, which are twice as large as thoſe of the female worm.
b b The horns, and the diſtinct articulations of them.
c The forceps, mouth, or dentated jaws, by which they dig into the earth.
d d The firſt, ſecond, and third pair of legs, with their articulations or joints.
e The little bags or caſes of the wings, which encloſe the firſt pair of wings, like a tender little flower, ſhut up in its cup.
f f The gills, perpetually fluttering, very white and limpid, and covered with innumerable fine hairs.
g Three briſtly hairy tails, with their appendagee.

The rowing fins in *Fig.* I. and III. may alſo be ſeen.

FIG. V.

Oblong or hollow tubes, or cells, made in the mud or clay, in which the Worm of the Ephemerus creeps, and is moved and nouriſhed.

a a The tubes made in the mud by the largeſt worm.
b b The tubes that are hollowed out by the ſmalleſt worms.

FIG. VI.

The male Ephemerus freed from the firſt exuviæ, or ſkin, entirely ſtript of its former likeneſs of a Worm.

FIG. VII.

The Worm of the female Ephemerus, about to undergo in a little time its change, in which may be ſeen the wings through their little bags or caſes.

a a The little ſheaths, caſes, or bags of the wings, through whoſe ſmooth external little membranes may be ſeen diſtinctly, the folded wings lying hid within them.

FIG. VIII.

A female Ephemerus, ſtript, on the ſurface of the water, of its ſkin; and quitting the form of a ſwimming Worm is changed into a flying inſect.

FIG. IX.

The manner how the wings expand themſelves. But in the following XIVth *Tab. Fig.* I. *under let.* e e e *may be ſeen the natural foldings of the wings, which here ſeparate by degrees one from another.*

FIG. X.

The ſame wing, firſt ſmoothing its ſerpentine foldings, afterwards its oblong folds.

FIG. XI.

The ſame wing not entirely expanded.

FIG. XII.

The male Ephemerus, employed in changing its ſkin, which is very ſlowly completed on dry land. Here half the body is now ſtript of its ſkin. The ſkin is ſtript off the head, thorax, and legs, in the ſame manner as we draw our feet out of our ſhoes; but as to the wings, the ſkin is drawn off them in ſuch a manner, that the inſide is turned outward.

FIG. XIII.

A male Ephemerus, which has almoſt gone through the change of its ſkin, ſo that its double external wings aud tail might be taken only for a ſlender part as yet to be caſt off.

FIG. XIV.

The very ſlender caſt ſkins of the Ephemerus, which do not retain the form, as here repreſented, becauſe the parts in which the wings were included, are commonly wrinkled, and by that means change the form.

FIG. XV.

FIG. XV.

A male Ephemerus, which has caſt both its ſkins, changed into a flying inſect; whoſe legs, which in the worm-ſtate were ſhort, are now as long again as they were, but the tails which were before twice that length, are now become three times as long.

TAB. XIV.

FIG. I.

A diſſection of the Worm of the Ephemerus.

a a The pulmonary tubes, or two air trunks, running along each ſide of the body.

b b The tubes reaching to the brain and nerves.

d d d d d The pulmonary tubes tending to the muſcles of the abdomen, from one ſide; but from the other ſide are ſeen, at the ſame letters, the naked muſcles of the abdomen, with their tubes, alſo the oblique, aſcending and ſtraight muſcles, hidden partly under the former.

e e e The air pipes, or tubes, running to the ſpinal marrow.

f f f f f f The air pipes diſtributed through the ſmall guts, or ſeminal veſſels of the male. One of them repreſented in its natural ſituation, and another of them removed out of the body, and repreſented magnified more than the other.

g g g g g The air pipes diſtributed to the gills. Only two of the gills are here repreſented, the other ten being cut off, to give an opportunity of ſeeing the ten rowing fins underneath them. See let. *r r r r*.

h The air pipes running to the loweſt parts of the inteſtines, and alſo to the ſpermatic veſſels placed near them. γ γ.

i i i The air pipes which ſupply, refreſh, and nouriſh the fat, membranes, and ſkin with air.

k k The air pipes.

p p p p Three exraordinary air pipes diſpatched beyond the body, towards the gills, cut off.

q q The middle of the three firſt pipes, being black, but about the middle ſhining with white, in ſuch a manner, that the black line of the gills appears as if marked with a white point oppoſite.

r r r r The five rowing fins ſtretched out from each ſide of the body, with ſtrong briſtly hairs, of an obſcure yellow gold colour,

s s A feathery little part ſituated underneath the firſt pair of gills.

y y y y The ſpinal marrow, conſiſting of eleven knots or ſwellings, from which ſpring the nerves that are diſtributed through the whole body. See *Fig.* VI. *Tab.* XV.

z z The parts to which the ſpinal marrow is faſtened, by the means of ſtrong ligaments.

* * The optic nerves, derived from the brain, or origin of the ſpinal marrow, where it forms the firſt knot or ſwelling.

α α The muſcles of the breaſt, employed in moving the legs.

β β The muſcles of the breaſt, employed in moving the wings, cut off.

γ γ Two little parts, which I take for the ſpermatic veſſels of the male.

δ The ſtraight gut cut off, in *Tab.* XV *Fig.* V. that it may be the more perfectly ſeen.

ε ε ε The extremely artificial folding of the wing, whilſt it yet lies in its caſe or ſheath, *k k.* being very eaſy to be unfolded. See *Fig.* IX. X. XI. *Tab.* XIII.

FIG. II.

All the parts juſt now repreſented in their natural ſize.

TAB. XV.

FIG. I.

l l Some branches of the air pipes which run to the ovary of the Ephemerus.

m m m m The ſame air-pipes running into and over the membrane inveſting the ovary.

c c The muſcles employed in moving the ſix gills and five rowing fins, placed on each ſide of the body.

f f The ſtomach and inteſtines, which are viſible through the membranes of the ovary. See *Fig.* V. of this Table.

i i The muſcles of the ſtraight gut employed in voiding the feces.

FIG. II.

The little eggs of the Ephemerus, as they appear to the naked eye.

FIG. III.

The double ovary of the Ephemerus, conſiſting of innumerable little eggs.

FIG. IV.

o o o o Some air pipes leading to the heart of the Ephemerus, partly cut off.

t t Part of the heart, like an oblong tube, which is ſomewhat ſwollen on each ſide.

v v v v Some air pipes cut off, leading towards the heart, and then to other parts.

x x x x The parts in which the tube of the heart ſwells up a little.

FIG. V.

a Part of the oeſophagus or gullet, cut off near the ſtomach

b The pylorus of the ſtomach

c The ſtomach itſelf, with certain air pipes, which creep all over it.

d d The ſmall gut continued from the ſtomach.

e The thick gut or colon, diſtinguiſhing itſelf by ſome little oblong tranſparent channels or furrows.

f The ſtraight gut elegantly folded, or wrinkled.
g Certain ſemilunar little valves of the ſmall gut.
4 5 6 7 8, *&c.* Eleven annular ſections, into which the body is divided.

FIG. VI.

The brain, ſpinal marrow, and the nerves, ſpringing from thence, according as they are placed in the living Ephemerus.

1 2 3, *&c.* The natural ſituation of the ſpinal marrow in the body of the Ephemerus. At the ſame time is ſhewn how the annular interſections are placed.

FIG. VII.

n Air pipes together with a part of the ovary, drawn out of the body, the more conveniently to ſhew how theſe pipes ſtick faſt to the eggs.
g The eggs, of a plain round oblong figure.

TAB. XVI.

No. I The Ant's egg delineated in its natural ſize, or the Worm of the Ant in its firſt ſkin or coat, wherein it is called an egg; which is exhibited in the firſt figure magnified.
II. The beforementioned covering, being quitted by the Worm of the Ant, is rolled up as into an inviſible point.
III. The Worm of the Ant come forth from the egg, with its parts imperfect; delineated in its natural ſize and ſituation. Figure the ſecond repreſents it magnified by the microſcope.
IV. The ſame Worm at the full period of its increaſe, all the parts of the Ant being contained hidden within it. Figure the third ſhews it as magnified.
V. The ſame Worm ſtript of its ſkin, and now called a Nymph.
VI. The ſame, having quitted the form of a Nymph, changed to a real and perfect Ant.

FIG. I.

The egg of the Ant magnified.

FIG. II.

The Worm of the Ant, as delineated under the microſcope, with its head bent towards the breaſt; called improperly the egg of the Ant.

FIG. III.

The former Worm, having arrived at its full bigneſs, about to quit by and by it skin, in order to be changed into a Nymph. This is alſo larger than naturally.

FIG. IV.

The Nymph of the Ant delineated by the aſſiſtance of the microſcope, which is repreſented No. V. *in its natural ſize.*

FIG. V.

The ſame Nymph, lying on its back, magnified.

FIG. VI.

The ſame Worm delineated again, as it appears under the microſcope; and all it parts diſtinguiſhed by annexed letters.

a a The two eyes in the head. *b* The teeth.
c c The horns, folded near the legs, upon the breaſt.
d d The firſt pair of legs.
e e Another pair of legs, viſible under the firſt.
f f The third pair, laid on the belly.
g The rings of the belly, and margin or border of the belly.

FIG. VII.

The Ant having completed all its labours, and now attained the full maturity and ſtrength of it age, exhibits the number of its parts and limbs complete.

a The teeth of the Ant, in which it carefully carries its Vermicle, or little Worm.
b b The two very black eyes.
c c The horns, of a light red colour.
d The ſix ſharp pointed prominences, into which the rings of the thorax divide themſelves.
e The loins, conſiſting, as it were, of three knotty joints or vertebræ.
f f Six hairy legs, compoſed of four joints.
g The ſhining hairy abdomen.

FIG. VIII.

The male Ant, in its natural ſize.

FIG. IX.

The male Ant, delineated as magnified, in which all the parts are diſtinctly repreſented.

a The teeth, a little leſs.
b The eyes, on the contrary, larger.
c c The horns.
d d Four wings, peculiar to the male, the firſt pair of which are much ſtronger and larger than the hinder ones.
e The loins, and
f The belly are both differently formed than thoſe parts are in the working Ants.

FIG. X.

The female Ant, in its natural ſize.

FIG. XI.

The female Ant, repreſented magnified; that the external difference between it and the other kind may be made to appear.

a The teeth.
b b The eyes.
c c The horns.
d The thorax.
e e The legs.
f The loins.
g The belly.

FIG. XII.

The little bag or caſe, in which the Worm of the Ant, being ſhut, is changed into a Nymph; as yet entire, and of its natural ſize.

FIG. XIII.

The ſame, opened.

FIG. XIV.

Another kind of Ant, found in Holland.

FIG. XV.

A ſixth kind of Ant, found alſo in Holland.

FIG. XVI.

The largeſt kind of Ant, found at the Cape of good Hope.

TAB. XVII.

Which repreſents Bees.

FIG. I.

The common or labouring Bee, whoſe external parts, are particularly deſcribed in the following figure.

FIG. II.

The ſame labouring Bee, in which all its external parts are diſtinctly pointed out by annexed letters.

a a The two oval eyes of this Bee, which are much ſmaller than thoſe of the male Bee.
b The particular little eyes, placed in the middle between the two former larger ones.
c c The antennæ or horns.
d A kind of horny or bony lip, which is not obvious in the males.
e e Two long teeth, which are ſhorter in the female, and very ſmall and ſhort in the male Bees.
f The long proboſcis or trunk, which is much ſhorter in the male.
g The thorax is roundiſh, and in the upper ſide of the hinder part it is provided with a ſomewhat prominent margin or border.
h h The two upper wings.
i i The two lower wings, which are leſs than the former.
k k The two foremoſt legs.
l l The two middle legs.
m m The two hinder legs, larger than the former ones, and that particular part of them which we call the foot.
n n The claws of the feet.
o o Part of the hinder legs, which is called the ſhank, the foot of which of one extreme part, is joined to another part called the thigh.
The abdomen. *q* The aculeus or ſting.

FIG. III.

The female Bee, commonly, but improperly, called the king. By comparing this with the common or working Bee, repreſented in the laſt figure, and with that of the male in the following figure, the difference between the three kinds may be obſerved.

FIG. IV.

The male Bee, which differs from both the female and working Bee.

FIG. V.

The proboſcis of the Bee, with its parts as repreſented by the microſcope.

a a The firſt pair of joints of the proboſcis, which are partly of a ſubſtance between horn and bone, and partly of a membranaceous ſubſtance, and here and there are covered with rough hairs. This cut repreſents them a little drawn in, and in readineſs to move the proboſcis backwards, and withal to compreſs and cover it; and likewiſe to force the honey through it towards the ſtomach.
b b The air-tubes, diſtributed through that part of the proboſcis, which is of a ſubſtance between horn and bone; and which, by being tranſparent, affords a view of them.
c c The extremities of the firſt pair of joints; theſe extremities are a little crooked.
d d The articulation of theſe joints with the root of the proboſcis.
e e The next pair of joints belonging to the proboſcis, conſtructed much after the ſame manner with the firſt. This ſecond pair greatly aſſiſt the proboſcis in its ſuctions.
f f The lower articulation of theſe joints, of a pretty conſiderable length.
g g The two upper articulations of the ſame joints, which are ſhorter.
h h The third pair of joints forming the proboſcis, which are ſomewhat of a ſubſtance between bone and horn, but for the greateſt part membranaceous, and likewiſe covered with rough hair. Theſe joints alſo are of ſervice to the proboſcis in ſucking the honey, which

which they likewiſe help to forward towards the ſtomach.

i The ſeventh joint of the proboſcis, being a ſingle one; or the proboſcis itſelf, conſiſting partly of a membranaceous ſubſtance, and partly of a ſubſtance between bone and horn. It is the underſide of it that I have here repreſented, as it may be ſuppoſed to appear, on turning the Bee upon its back.

k k Part of the proboſcis itſelf, of a ſubſtance between bone and horn, conſtructed in ſuch a manner, that the Bee can ſeperate it from the main body of the proboſcis, and give it a circular form.

l The gullet repreſented cut off.

m The membranaceous part of the proboſcis itſelf, which lies beautifully folded up under the other portion of the proboſcis juſt now mentioned, as conſiſting of a ſubſtance between bone and horn.

n n The part of the proboſcis which conſiſts of a ſubſtance between bone and horn, tending inwardly, and forming, as it were, a narrow channel.

o o The fore extremity of the proboſcis covered with crooked hairs, and furniſhed with a little head, in which there is a hole that ſeems to be the cavity of the membranaceous part.

p That part of the proboſcis, which conſiſts of a ſubſtance between bone and horn, divided at its fore extremity into two ſhanks.

q q q Three very black, but ſhining, joints of the proboſcls, of a ſubſtance between bone and horn, and forming the lower part of the proboſcis. The middle of theſe joints is the ſheath or caſe of the proboſcis, and is furniſhed with muſcles, which belong to the ſecond pair of joints *e e* of this organ. But the two extreme joints of the part now before us, contain muſcles that adminiſter to the firſt pair of joints *a a*.

r r r r The articulations by which the three joints *q q q* are united with the parts of the head.

s s The ſtrong muſcles ſerving to move inwards the proboſcis, its joints and ſheath.

t A thin tranſparent membrane, through which the muſcles *s s* may be diſcerned.

FIG. VI.

More diſtinctly exhibiting in what manner that part of the proboſcis, which conſiſts of a ſubſtance between bone and horn, and which is repreſented under the letters k k Fig. V, *can form itſelf into a circle, and dilate the membranaceous parts of the proboſcis at the time of its ſuction.*

a a a That portion of the proboſcis, which conſiſts of a ſubſtance between bone and horn. This part is much blacker and ſtronger in the middle of it than elſewhere, as is very diſcernible.

b The circular form or bending which that part acquires at the time of ſuction.

c c c c The expanſion, in form of a ſail, of the membranaceous part of the proboſcis, that lies folded up under the other part that conſiſts of a ſubſtance between bone and horn. The former part acquires the ſaid form, when the latter projects itſelf in that of a circle.

d The papillæ, or glandalous protuberances of the membranaceous part of the proboſcis. Theſe particles appear moſt viſible when the ſaid part is expanded.

e The place where that part of the proboſcis, which conſiſts of a ſubſtance between bone and horn, tends inwardly, and uniting with the remaining hairy part of the proboſcis, forms, as it were, a narrower channel.

f The fore extremity of the proboſcis, covered, as it were, with crooked hairs, and perfoforated in the middle.

g The hairs of the proboſcis, which are not of an equal thickneſs, but ſomewhat bigger near the roots.

FIG. VII.

The proboſcis of a Waſp, viewed on its lower ſide.

a Part of the proboſcis of a horny ſubſtance, which conſtitutes the lower part of the inſect's head. This part is covered with hair on its ſides, and is all of a ſhining black, except two yellow ſpots.

b b c Three horny particles or joints, which ſerve in a manner to form the root of the proboſcis. The two lateral *b b* contain the muſcles, that govern the briſtles *d d*; but the middle joint *c* ſerves, as it were, for a caſe or ſheath to the proboſcis.

d d d d Four articulated briſtles, which aſſiſt the proboſcis in its ſuctions.

e e The place where the teeth are broken off.

f The proboſcis itſelf, adorned with four beautiful white particles, or rather protuberances, that terminate in little round knobs.

FIG. VIII.

The hair of a Bee, as it appears through the microſcope, in the form of a feather.

a The ſtem, as it were, of the feather.

b b The ſmaller lateral branches ſpringing from the ſtem.

c The hairy extremity of the ſtem.

FIG. IX.

The lungs of the Bee.

a a The pulmonary veſicles of a white colour.

b b &c. The little tubes branching from theſe veſicles; they conſiſt of ſpiral rings, which in this place are always open.

c c &c. Other veſicular dilatations of the pulmonary tubes, which again degenerate into the tubes *d d &c.*

e e &c. Ramifications of the pulmonary tubes diſtributed through the body.

f f Two places, where the greater pulmonary veſicles have a direct communication with each other.

FIG. X.

The pulmonary tube, which conſiſts of rings, and is here repreſented as it appears when drawn out, the better to exhibit the ſpiral courſe of theſe rings.

TAB. XVIII.

FIG. I.

The internal parts of a Bee.

a The gullet.

b The ſtomach, furniſhed with fleſhy fibres.

c The pylorus, conſiſting of nodules, and full of a ſubſtance of a yellowiſh red colour.

d d The ſmall gut, very ſpacious or wide, full of muſcles, and furniſhed with valves.

e e e The vaſa crocea, or yellow gut-veſſels; being an infinite number of little inteſtines moſt intricately connected, and moſt firmly united with the narroweſt part of the ſmall gut.

f The narrow part of the inteſtine.

g The ſudden dilatation of the inteſtine, that ſucceeds the conſtruction of it juſt now mentioned. In this place the inteſtine looks like a membrane, and exhibits ſix protuberant glandulous particles on its inner ſurface, as beſt appears by the particular figure placed at one ſide of that now under our conſideration.

h h The ſaid ſix glandulous particles, as they appear more plainly on opening the inteſtine that contains them.

i The place where the inteſtine, after dilating itſelf, narrows a ſecond time. I have given a particular figure to illuſtrate this narrowing.

k The place where this inteſtine appears full of folds, like a rumpled piece of linnen.

l The ſtraight gut, over which the ſting lies.

m m The hinder part of the laſt abdominal ring, which is covered with hair, and gives a paſſage to the ſtraight gut.

n n Six particles or joints, of a ſubſtance between bone and horn, which are articulated with the ſhanks of the ſting.

o o Two appendages always found along with the ſting, and placed on each ſide of the ſting and the ſtraight gut.

p The bag containing the poiſon, which the Bee injects into the wound made by the ſting.

q q The blind extremities of the tube that ſerves to ſecrete the poiſon, and afterwards conveys it to the bag that is to contain it.

FIG. II.

Repreſenting the ſting, and all its parts.

a The ſting, compoſed of a ſheath or caſe, and two ſhanks, united to each other, and terminating in a ſharp point, ſo as to look like a ſingle part.

b The poiſonous bag.

c The tube that ſerves to convey the poiſon from its bag, to the thickeſt part of the ſting's ſheath.

d d The two ſhanks of the ſting, mutually conveying to each other.

e e The ſheath of the ſting.

f f The thickeſt end of the ſheath, where the tube opens into it, by which it receives the inſect's poiſon.

g The extreme point of the ſting, formed by the two ſhanks of that organ, that are in this place cloſely united.

h h The beards with which the ſhanks of the ſting are armed at their extremities.

e The tube that ſerves to ſecrete the poiſon, which it diſcharges into the poiſon-bag.

k k The two blind extremities of ſaid tube.

l l l l l l Three pair of cartilages, of different forms, which are for the moſt part of a deep black, and articulated among themſelves, and with the ſhanks of the ſting.

m m Two other cartilages leſs conſpicuous than the former, with one pair of which they are articulated. Theſe two cartilages *m m,* are almoſt entirely of a membranaceous ſubſtance.

n n n n n n n n Eight places in which the foregoing cartilages are articulated among themſelves, and with the ſhanks of the ſting *d d.*

o o o o Four muſcles ſerving to move the ſting different ways, by the aſſiſtance of the ſame cartilages.

p p Two muſcles which draw the ſhanks of the ſting into its ſheath.

q q Two appendages of the ſting which are moved along with it, and ſeem to anſwer no other purpoſe but that of ornament.

FIG. III.

Which again exhibits, but in a more diſtinct manner, the ſting and other parts relating to it.

a The thick or blunt extremity of the ſting's ſheath, into which the inſect ſheds its poiſon.

b The ſharp extremity of the ſting's ſheath, to which the poiſon runs, under the ſhanks.

c c The place where the channel of the ſheath grows narrower, the better to retain the ſhanks that are within it, in their proper ſituation. This particular may be ſtill better diſcerned under the letters *d d.*

d d The ſhanks of the ſting laid up within the channel of the ſheath, and beautifully retained in their proper ſituation by the two proceſſus of the ſheath, already taken notice of under the letters *c c.*

e e e The borders or edges of the ſting's ſheath, which are turned in, and received by the channels of the ſting's ſhanks, and not only ſerve to retain the ſting in it's ſheath, but likewiſe allow it leave to move freely.

f One of the ſting's ſhanks put ſomewhat more forward within the ſheath than the other ſhank; but after ſuch a manner, however, that the ſting's point ſtill remains entirely within the ſheath.

g The other ſhank of the ſting, lying higher within the ſheath. We may here ſee by what means the ſting, left in the wounds made by it, penetrates deeper and deeper.

h The hollow, cavity or channel of the ſting's ſheath, when wideſt.

i The narroweſt part of the ſaid hollow, cavity, or channel.

k One of the ſting's ſhanks repreſented by itſelf, ſo as to exhibit

l l The cavity or channel within which the edge of the ſheath is received, ſo as to afford the ſhank a free motion.

m A ſegment of the ſhank cut off tranſverſely, to give a better view of the ſhank's cavity or channel.

n The ſame channel or cavity, as it appears in the other branch.

o The extremity of the ſhank's channel or cavity.

p Ten crooked heads or beards, with which each ſhank is generally furniſhed.

q q q Other leſs conſiderable hooks or beards.

r r r Certain proceſſes of a ſomewhat cartilaginous ſubſtance, and ſerving, inſtead of muſcles, to move the ſhanks.

s s s The ſmooth unbearded ſides of the ſhanks, by which they join each other.

t t t The hinder parts of the ſhanks, or the ligaments by which they are thruſt out.

v v Two places in which the ſting appears as if there was a joint in it. But this appearance is entirely owing to the air, which makes it appear uneven: the poiſon ſticking to the ſheath.

x The poiſon bag.

y The tube which conveys the poiſon of the bag.

z The tube by which it diſcharges its poiſon.

FIG. IV.

The poiſon bag of the Waſp, and the Hornet, with the other parts belonging to it.

a The poiſon bag

b The tube by which the ſaid bag ſheds its poiſon.

c c The two tubes inſerted into the hinder part of the poiſon bag, into which they diſcharge the poiſon. In the Bee there is but one tube to anſwer this purpoſe.

d d d Swellings here and there in the laſt mentioned tubes.

e e The ends of the tubes ſomewhat thicker than any other part.

FIG. V.

Repreſenting the manner, in which the Bee's poiſon may be extracted or gathered.

a A ſlender glaſs tube ſerving to receive the poiſon.

b The point of the ſting placed within the tube, and pouring into it the poiſon ſqueezed by the fingers out of the poiſon-bag.

TAB. XIX.

FIG. I.

The Bee's heart, with the parts belonging to it.

a a Part of the heart ſeated in the upper region of the abdomen.

b b b Pulmonary tubes running towards each ſide of the heart, in which they at laſt terminate.

c c c c c c Certain thin membranes, that ſerve to keep the fat in its proper place.

d d The fat as it appears through the ſaid membranes, which are tranſparent.

e e e The ovary, as it likewiſe appears through the ſaid membranes.

f f f f f The muſcular fibres broken off from the abdominal rings, which they ſerve to govern.

1 2 3 4 5 6 The ſix abdominal rings under which the heart is placed, as it were in the inſect's back.

FIG. II.

The ovary of the Bee, of the ſize and form it appears to the naked eye.

FIG. III.

The ſame ovary, repreſented as it appears through the microſcope.

N. B. This double ovary is compoſed of parts extracted from two different female Bees, *viz.* The part *a* from a full-grown impregnated Bee; and the part *c* from another Bee leſs perfect, and not as yet impregnated. This I did to avoid the neceſſity of two figures, where I thought one might be made to anſwer.

a Part of an ovary extracted from an impregnated Bee, furniſhed with an infinite number of ducts, that contain eggs of different ſizes.

b b The coalition of the oviducts of each ſide, where they diſcharge their eggs into a common channel or duct for all the eggs of that ſide.

c Part of an ovary extracted from a female unimpregnated Bee. The eggs of this part differ greatly from thoſe of the other part *a*.

d A dilatation of the pulmonary veſicle, which diſtributes its ramifications, and an infinite number of air-tubes through every part of the ovary, its ducts, and even the eggs themſelves.

e e The upper parts of the oviducts of an impregnated Bee, where they unite, and the two parts of the ovary bend towards each other.

f f The upper parts of the oviducts of an unimpregnated Bee, in which they are hereabouts very ſlender, contain but very minute eggs, but which bend in the ſame manner mentioned in the preceding article.

g g The eggs of the ovary of an impregnated Bee, which are ſenſibly bigger and bigger, the nearer they approach the common oviduct of the ſide, to which they belong.

h h h The eggs of an impregnated Bee, which are in every oviduct almoſt of the ſame ſize, at the ſame diſtance from the common oviduct.

i i i The eggs in the extremities of the oviducts of an unimpregnated Bee's ovary. Theſe eggs are not only very ſmall in themſelves, but ſmaller, paler, ſhorter, and more delicate than thoſe in the extremities of the impregnated Bee's ovary.

k k k k k k The eggs in both parts of the ovary, ready to fall into the greater common duct.

l l l l The eggs of an unimpregnated Bee, differing in ſize, but very irrregulary, ſome of thoſe furtheſt from the common duct being bigger than the others that are much nearer, contrary to what appears in the impregnated Bee, as has been already obſerved under the letters *g g h h.*

m m The eggs in the extremity of an impregnated Bee's ovary, which are bigger, and of an oblong, and more regular form.

n n Two common ducts, or, as it were, the horns of the uterus, in which all the particular oviducts terminate, and pour their eggs.

N. B. Both theſe ducts are extracted from an impregnated Bee, though one of them ſupports the ovary of an unimpregnated one.

o o The place through which the ſpinal marrow takes its courſe.

p p Part of the common duct, more ſpacious than the reſt, furniſhed with muſcles, or of a muſcular conſtruction, and within which are placed

q q q q q q A great number of eggs ready to come away; theſe eggs appear a little through the duct, which is tranſparent.

r r r r r Air-tubes, running through the horns and the common duct of the ovary.

s The coalition of the two common ducts or horns into one narrower channel, which is likewiſe muſcular, and the excretory duct of the Bees eggs.

t A globular or little round part or organ, containing a glutinous matter, with which the eggs are ſmeared over before the Bee lays them. The interior coat of this bag is curiouſly interwoven with an infinite number of air-tubes.

u u Two blind veſſels, that, after making a great many turnings, meet, and form a ſingle tube. This tube terminates in the uterus, or excretory duct of the eggs, and ſerves perhaps to ſecrete the glutinous matter juſt now taken notice of, and to convey it to the bag deſtined to receive it.

x The exitus, or end of the uterus, or of the excretory duct of the eggs, as yet not ſufficiently examined.

y y The external muſcular parts of the ſting, broken off.

z The poiſon-bag, with

α Its ſingle ſecreting tube, and

β β The blind appendages of the ſaid tube.

γ The tube by which the poiſon is diſcharged.

δ The ſting of a female bee, naturally crooked.

ε ε Two little parts placed by the ſides of the ſting, and already taken notice of in the anatomy of the working Bee.

ζ The ſtraight gut.

FIG. IV.

The ovary of a Waſp.

a a The oviducts of this ovary repreſented by themſelves, being ſeven of a ſide.

b b b The upper part of the ovary, extending to a very great length.

c The bag containing a glutinous matter, with its ſecretory veſſels. This bag is ſhaped like a pear.

d d Some minute eggs, of the common oval form.

e The meeting of the particular oviducts in one common oviduct.

FIG. V.

The egg of a Bee, repreſented by itſelf.

a The egg, of its natural ſize.

b The ſame egg ſeen with the microſcope, which ſhews an infinite number of air-veſſels, diſtributed all over the egg's ſurface.

c c The oviduct cut off at each end of the egg.

FIG. VI.

The poiſon-bag of the Bee, of its natural ſize.

b The poiſon-bag repreſented under the letter *z* of Fig. III. as it appears through the microſcope.

c c Two blind appendages which ſerve to ſecrete the poiſon, and afterwards meet ſo as to form

e A ſingle tube, terminating in the body of the bag.

TAB. XX.

FIG. I.

The head of the Male Bee, with the parts belonging to it, eſpecially the eyes, which are here repreſented much bigger than in nature.

a Three ſingular, or particular unequal eyes, which in the male Bee are placed in the form of a triangle between, but lower than the greater eyes; but in the female and working bees, theſe unequal eyes appear in the upper part of the head.

b b One of the greater eyes, eſpecially the ſuperior external face of it, which is by no means pointed, but of a roundiſh form.

c The internal inferior edge of the greater eye, which is ſomewhat pointed, ſo as to leave an intermediate ſpace for the reception of the ſmaller eyes, and other parts.

d Feathered hairs, or hairs in form of feathers, growing in the ſpace between the greater eyes.

e e e Hairs with which both eyes are well ſupplied, and which too anſwer the purpoſe of eye-brows or eye-lids.

f f The Antennæ or little horns.

g g Fibres of an inverted pyramidal and hexagonal form, which immediately appear on removing the cornea, and uvea of the eye.

h h The upper part of the ſaid pyramidal fibres of a pretty conſiderable breadth.

i The lower part of the ſaid fibres, where they terminate in a point; likewiſe the internal coat of the eye, upon which theſe fibres ſtand.

FIG. II.

The diſpoſition or ſituation of the hexagonal diviſions of the cornea.

k k A hexagonal diviſion encloſed by ſix other ſimilar diviſions; and this order, or diſpoſition, or arrangement, obtains all over the cornea, and all its diviſions.

FIG. III.

A ſmall portion of the Cornea, along with its hairs, as ſeen through the microſcope.

l l l The thickneſs of the cornea, which is pretty conſiderable.

m m m Hairs like briſtles, growing out of the Cornea, which they even perforate with their roots. Theſe hairs project a conſiderable way beyond the ſurface of the cornea, and anſwer the purpoſes of eye-brows and eye-lids.

FIG. IV.

The cortical lower fibres of the eye.

n n n The cortical fibres of the eye, which lie like beams or joints on the membranes that ſupport the upper pyramidal fibres.

o The manner in which theſe fibres are placed one over another, like beams intended to form a raft.

p The brain, ſituated under theſe fibres, and communicating with them.

FIG. V.

The eyes and brain, as they appear on beginning the diſſection of them on the lower ſide.

q q The cortical fibres of the eye, ſhewing in what manner they lie tranſverſely or acroſs, under the membranes, that ſupport the pyramidal fibres, and are diſtributed like the muſcular fibres in the papillæ of the kidneys.

r The origin of the ſpinal marrow.

s s The cortical ſubſtance of the brain divided in the middle, and covering in part the cortical fibres of the eye.

t t The manner in which the cortical ſubſtance of the brain, communicates at each ſide with the ſpinal marrow.

u u The thickeſt part of the cortical fibres, and the place where they have the moſt apparent colour.

x The internal coat of the eye, ſupporting the inverted pyramidal fibres.

y The firſt nodule or ſwelling, formed by the ſpinal marrow, after its leaving the ſkull.

z z The pyramidal fibres of the eye, as they appear on each ſide, when juſt diveſted of the cornea.

FIG. VI.

The brain more accurately diſplayed.

a a The cortical ſubſtance of the brain, ſhewing, not only in what manner it communicates with, but likewiſe ſprings from the brain.

b The ſecond pair of the particles of the brain, from which the cortical ſubſtance derives its origin.

c The firſt pair of the brain's particles, from which iſſue *d d* Bipartite nerves.

e e The fourth pair of the brain's particles, ſhewing likewiſe in what manner the particles of every pair communicate with each other.

TAB. XXI.

FIG. I.

The genital parts of the male Bee, as they appear through the microſcope,

a a The two teſticles.

b b The vaſa deferentia, twining or curling like the tendrils of a vine.

c c The ſame veſſels conſiderably dilated, ſo as to appear like a ſecond pair of teſticles. Theſe veſſels are hollow.

d d The ſeminal or ſeed bags, into which the vaſa deferentia, after growing narrower again, are inſerted on each ſide.

e e The nervous root of the penis.

f A little part or particle of a ſubſtance between bone and horn, of a deep brown, ſomewhat inclining to red, placed within the oval tube, wart or tubercle of the penis.

g The penis, or part like a penis, but without any perforation.

h A ſmall part divided into five diviſions.

i Another particle, ſeated, as it were, oppoſite to the former *h* but without any diviſions. This particle is ſhaggy on its inſide, rugged, and full of wrinckles.

k k Hollow, pointed appendages.

l l Ligaments, ſerving to faſten the genital parts in the abdomen,

m A portion of the ſpinal marrow, from which proceed

n n The nerves, that are diſtributed over the genital parts, and ſerve to move them, as likewiſe the purpoſes of ſecretion and pleaſure.

FIG. II

o The genital parts of the male Bee, of their natural ſize.

FIG. III.

The genital parts of the male Bee, beginning to unfold themſelves.

c c The vaſa diferentia cut aſunder in their thickeſt part, to ſhew their thickneſs and cavity.

d d The ſeminal bags cut aſunder for the ſame purpoſe.

e e The nervous root of the penis.

f f A little horny bone, ſituated in the bulbous portion of the root of the penis.

h The five-fold little particle, beginning to unfold itſelf.

i The other particle, without any diviſion, beginning likewiſe to unfold itſelf.

k k The ſharp, hollow appendages coming out of the body

q q The horny bone, conſtituting the extremity of the pudendum,

s s Certain particles ſerving as ornaments to the ſaid bone.

FIG. VI.

The genital parts of the male Bee, a little more unfolded.

e The nervous root of the penis.

f The little horny bone placed within the tubercle of the root, further thruſt out.

h The quinque fida, or five-fold particle further thruſt out.

i The other particles without diviſions, alſo more thruſt out.

k k The ſharp, hollow appendages quite unfolded from their roots, but

l l Their points ſtill continue out of ſight.

q q
r } Denote the ſame parts, as in the laſt figure.
s s

TAB. XXII.

FIG. I.

The genital parts of the male Bee, ſtill further thruſt out.

e The nervous root of the penis.

f The little horny bone lying within the tubercle of the root.

h The five-fold particle ſtill more unfolded.

i The other particle, that has got no diviſions, further thruſt out.

k k The hollow appendages quite inverted, or turned inſide out.

q q
r } Denote the ſame parts, as in the figure of the laſt plate.
s s

FIG. II.

The ſame parts yet more unfolded.

e The root of the penis beginning to grow ſtraighter.

h h The five-fold particle quite unfolded, and exhibiting its five diviſions.

i The other undivided particle entirely diſplayed in like manner.

k k The appendages perfectly inverted, or turned inſide out, and ſtiffened.

q q
r } Denote the ſame as before.
s s

FIG. III.

The genital parts of the male Bee unfolded to their utmoſt extent.

e The root of the penis extended, for the moſt part within the pudendum.

f The little horny bone ſeated in the tubercle of the root, now entirely thruſt out of the body, and appearing through the tranſparent parts which encloſe it. The five-fold particle, is now ſo much dilated, as to be almoſt out of ſight, by lying backwards upon the hairy part of the pudendum.

g The penis, or particle reſembling one, now perfectly inverted, or turned inſide out.

i The undivided pyramidal particle in like manner unfolded and diſplayed.

k k k The appendages as before, perfectly unfolded, and turgid withall.

q q
r } The ſame parts as before.
s s

t The head of the peniform particle beautifully plaited.

u A conſiderable opening, or perforation under the penis, and at the bottom of, and between the diviſions of, the little horny bone. already ſo often taken notice of. The Bee's ſeed iſſues copiouſly at this opening.

FIG. IV.

x The head of the peniform particle, which, however, has no opening, and affords no paſſage to the ſeed.

FIG. V.

The genital parts of the greater Hydrocantharus, or Water Beetle.

a The penis.

b b The horny part of the penis, ſerving to faſten it on each ſide.

c c The root of the penis,

d The other teſticle in its natural ſituation.

e The teſticle ſtripped of its air tubes, ſo as to exhibit its internal ſtructure.

f f The vaſa diferentia.

g g The thickeſt part of the ſaid veſſes.

h h h h h h Seven blind veſſels rooted in the penis, and anſwering perhaps the purpoſe of proſtata.

i i The ſeed bags neatly curled at their extremities.

FIG. VI.

The ſpinal marrow of a male Bee, ſeen through the microſcope

a The origin of the ſpinal marrow.

b b 1 2 3 4 5 6 7 Seven nodules, formed by the ſaid organ in its progreſs, and the nerves iſſuing from the ſaid nodules.

c c c c Some nerves which ſpring not from the nodules, but from the branches themſelves of the ſpinal marrow.

d a d d, &c. Clefts, or longitudinal perforations in the ſpinal marrow.

e That part of the ſpinal marrow, which lies in the head and neck.

f That part which lies in the thorax.

g That part which lies in the particle joining the thorax and abdomen.

h The abdominal part of the marrow.

i i Two conſiderable nerves diſtrubuted to the jaw bones, and other parts.

k k Two nerves running to the proboſcis. Theſe are perhaps the inſect's guſtalory nerves.

l l Two other nerves, adminiſtering to the guſtatory nerves of the proboſcis.

m m Two nerves, perhaps the optic ones; but I advance this with diffidence.

o o Two ſtrong nerves, diſtributed to the genital parts.

FIG. VII.

Part of the ſpinal marrow, as it appears under a greater magnifier.

p p p p p p The branches, or ramifications of the ſpinal marrow, and the nerves cut away from about the nodules.

q q q q The external ſubſtance of the marrow, reſembling as it were a cleft or divided nerve.

r Another part of the marrow lying between the medullary ſubſtance, and forming the nodules.

TAB. XXIII.

FIG. I.

The ichnography of a regular honey-comb of the working Bees, as it appears, when inſpected from above, divided into its regular hexagonal ſections. This deſcription could not be accurately ſketched out, without the aſſiſtance of ſome artificial lines.

a A regular hexagonal cell, formed by artificial lines.

b b Double tranſverſe lines, ſerving to determine the angles of the cells.

c c Longitudinal lines croſſing the former.

d d Conſtitute the ſides and diameters of the cells.

FIG. II.

Four cells of the working Bees, ſeparated from the other cells.

a Three cells joined ſide by ſide to each other, and forming by the union, or meeting of their baſes, a cavity exactly fitted to receive.

b The bottom of a fourth cell, in caſe the Bees ſhould build one. Thus it may be ſeen, in what manner three cells, built one cloſe to another, form by the ſides of their bottoms a foundation for ſupporting the bottom of another cell, to be built a contrary way.

c Part of a triangular foundation ſloping downwards, and of the cell built upon the ſaid foundation. This is formed by the meeting of the ſides of two cells.

d d Two pretty long, or longer and unequal angles, or corners, formed by the hexagonal ſides of the ſame cell, and uniting with the former part *c*, ſo as to form the foundation of another cell.

FIG. III.

A ſingle, regular, hexagonal cell cut lengthwiſe through its centre.

a One entire third of the foundation, that is cut into two by this ſection.

b b The third part of a foundation, which foundation is cut away. One ſegment of this foundation remains united at one ſide with the third part laſt mentioned, and the other ſegment with the third part mentioned of the divided cell.

c The entire remaing third part of the divided foundation, ſticking to part of another cell.

1 2 3 4 5 6 The ſix ſides and angles or corners of the cell, as they mutually anſwered one to another.

FIG. IV.

Fifteen regular hexagonal cells, cut lengthwiſe on each ſide.

a b The upper cells. *c* The lower cells.

d The common foundation of the upper and lower cells, cut off.

e e e e The ſhorter ſides of the cells.

f f f f The longer ſides of the cells.

g The third part of a triangular foundation ſloping inwards, in its natural ſituation.

FIG. V.

A building, conſiſting of a great many cells for the reception of males and females, in order to ſhew in what particulars the ſaid cells differ one from another, and from the cells of the working Bees.

a The cell, or little houſe, of a female Bee, falſly called a king-Bee. This cell reſembles a pear, is irregularly built, with hollows here and there on its external ſurface, and is placed above the other cells.

c Cells of male Bees, one third bigger than thoſe of the working Bees. They are here repreſented ſomewhat bigger than nature, the better to ſhew the difference.

d The triangular foundation of the ſaid cells, which appear the better by removing the cells themſelves.

e Triangular cavities, formed each by three ſimilar cells of an oppoſite ſide or row, that are built one againſt another. Theſe cavities receive the bottoms of the cells of the ſaid ſide or row, in the ſame manner with the cavities in the conſtructions of the working Bee, already taken notice of.

f Two cells, whoſe fore edges are ſo covered and faſtened with wax, that their hexagonal form cannot be ſeen.

g Four very irregular cells, forming a foundation for the king's cell. Theſe four cells ſerve, perhaps, no other purpoſe but that of keeping honey.

FIG. VI.

Four regular cells of the working Bees, built one cloſe to another, after ſuch a manner, that they all ſtick to one common or intermediate foundation, at the ſame time that five of them lie to the right, and the other five to the left.

a Five cells belonging to one ſide. Theſe cells taken together are an inch long, are joined to each other by their ſides; and their bottoms lie contiguous to, and ſupport, the cells of the oppoſite ſide.

b Five cells of the oppoſite ſide, of the ſame length with the former, and united to, and ſupporting them in the ſame manner.

c c The intermediate foundation, that ſerves as a common bottom to the cells on each ſide.

FIG. VII.

A ſingle, regular, hexagonal cell of a working Bee, divided into three parts; the better to ſhew in what form they are conſtructed.

a a a Three longitudinal ſegments of a cell, each of which contains two ſides and one angle.

1 2 3 The three undivided corners formed by the ſides of the cell.

44, 55, 66 The three divided angles that were formed by the ſeparated ſides.

b The bottom of the cell, divided in like manner into three parts; theſe parts united form a hollow triangular ſloping foundation. We may here ſee, how every two ſides of a cell form one part of a triangular bottom.

FIG. VIII.

Nineteen regular hexagonal cells built cloſe to one another, as they appear on their back parts.

a b The manner in which the cells of one ſide are laid out, ſo as to form every three of them, by the union of their three baſes, 1 2 3, a hollow, which ſerves as a foundation for a cell on the oppoſite ſide. For this reaſon, if you run pins through the three parts of 1 2 3 of the bottom of one cell, one pin through each part, every pin will penetrate into a different cell of the oppoſite ſide. And on the other hand, on running pins through the bottoms of three contiguous cells of the oppoſite ſide, in that part where the ſaid bottoms lie neareſt to each other, theſe pins will all meet in one cell.

FIG. IX. Letter *b*

The cell of a female Bee repreſented by itſelf, to exhibit the more diſtinctly its pear-ſhape form, narrow mouth, ſpacious bottom, its length, and the unevenneſs of its external ſurface.

FIG. X.

A building, conſiſting of nineteen cells, eighteen of which contain the rudiments of Bees. Nine of theſe eighteen cells have got in them eggs, placed on their ends, and four others contain young worms, that have but lately ſhed their ſkins; the five remaining cells contain Worms a little bigger, and better grown. Of theſe laſt, that marked with letter a *is the largeſt,*

FIG.

FIG. XI. Letter *a*.

Six eggs drawn after nature, and placed on their ends. Theſe eggs are oblong, very ſlender, but ſomewhat thicker on their upper parts.

FIG. XII. Letter b.

Another Bee's egg viewed with a microſcope. It reſembles the ſkin of a fiſh, diveſted of its ſcales, but ſtill retaining the marks of their inſertions.

FIG. XIII.

Worms of Bees of different ſizes, drawn after nature.

a A Worm newly hatched.

b c d e Four worms that received more nouriſhment, and are more grown.

f g Two worms ſtill bigger than the former, having had more time to make uſe of the nouriſhment provided for them. They are here repreſented, as they lie doubled in their cells.

h A Worm placed on its belly, ſo as to ſhew on its back a black line, inclining to a light blue or gray. This line denotes the ſtomach, which appears in this place through the tranſparent parts that lie over it.

i A Worm lying on its back, and beginning to draw in the hinder part of its body, and move its head.

FIG. XIV.

The full grown Worm of the Bee, viewed with the microſcope.

a a a Its fourteen annular inciſions or diviſions.

b The head. *c c* The eyes. *d* The lip.

e e Two ſmall parts, which afterwards form the antennæ or horns.

f f Two other ſmall, and as it were, articulated parts, which form the teeth.

g The rudiment of the tongue or proboſis.

h h h Ten breathing holes.

i The ſtomach appearing on the back through the parts encloſing it.

FIG. XV. Letter *a*.

The little houſe or neſt of a Hornet, compoſed of bits of barks.

FIG. XVI.

A Bees cell full of Bees bread, placed in layers.

b Little grains, of which the ſaid ſubſtance, viewed with the microſcope, appears to conſiſt.

TAB. XXIV.

FIG. I. II. and III.

Exhibiting the manner in which the pulmonary tubes, and breathing-holes of a Bee's worm, are conſtructed.

a a a 1 2 3 4 5 6 7 8 9 10 Ten pulmonary tubes, open on each ſide.

b b Tubes which reach in circumference from one breathing-hole to another, by which means there is a communication between all the holes.

c c The anaſtomoſis, or inoſculation of the pulmonary tubes belonging to the oppoſite ſides of the body.

d d d The breathing-holes, or orifices of the pulmonary tubes. Theſe holes lie naturally under the ſkin, though they are here repreſented, as if they projected beyond it.

e f Rings compoſing the pulmonary tubes. Some of theſe rings *e* are longer than others *f*.

g g The ſkin cut off.

FIG. IV.

The manner of finding out the blood-veſſels of Inſects.

a A glaſs tube, part of which bellies out in the middle.

b One of its ends drawn out to a very ſharp point.

c The other end, which is more open and wide than the former. It is at this end that the air is blown in.

FIG. V.

The tubes that prepare both the matter of which the Worm forms its thread, and help it to form them.

a The tubes themſelves in which the ſaid matter is prepared.

b The place where theſe tubes meet, and form one trunk.

c c The diviſions of the tubes.

d d d d The ends of the tubes, broken off.

FIG. VI.

Some of the viſcera of the Worm of a Bee.

a a The ſtomach.

b The oeſephagus or gullet.

c Glands appearing through the coats of the ſtomach.

d d Pulmonary tubes cut off from each ſide of the ſtomach, over which they ſpread an infinite number of ramifications.

e The tranſparent muſcles of the ſtomach.

f The pylorus.

g g g g Four blind veſſels or guts.

h h The inſertion of theſe veſſels under the pylorus.
i The other guts, or inteſtines, the thick and the ſtraight.
k The extremity of the ſtraight gut, with the ſkin ſtill adhering to it.
l The internal coat of the ſtomach, full of a cogulated mattter.

FIG. VII.

The web which the Worm of the Bee forms, and in which it afterwards encloſes itſelf.

a The lower part of this web. This part is of a membranaceous ſubſtance, pretty thick, and ends in a triangular point.
b The encloſed Nymph of the Bee, tranſparent in the middle.
c The upper part of the web. This part is convex, and the threads compoſing it are very diſcernible.

TAB. XXV.

FIG. I.

The Worm of the Bee, forming its web.

a a The ſides of the cell that contain it.
b The bottom of the cell.
c The entrance or door of the cell. The Worm is here repreſented as making its web in the propereſt manner to ſhut up this entrance.

FIG. II.

The Worm of the Bee taken out of the web, in which it had encloſed itſelf, and juſt ready to caſt its ſkin.

a The Worm of the Bee quite deſtitute of motion, after it has finiſhed its web, with which it is entirely ſurrounded.
1 2 3 The three annular inciſions, or diviſions next its head; the ſecond and third of which begin to be conſiderably diſtended, by the limbs growing under them.

FIG. III.

A cell, containing the Worm of the Bee changed into a Nymph, and perfectly lined with the ſaid Worm's web. Likewiſe the ſaid web entire, with the Nymph contained in it, as they appear on opening the cell.

a a The ſides of the cell, lined with the Worm's web.
b The mouth of the cell, perfectly cloſed by the web.
c The bottom of the cell.
d The web. entire, as it appears on opening the cell, which it greatly reſembles in form.
e The upper part of the web, of a convex form. This part ſhews its filaments pretty diſtinctly.
f The encloſed Nymph appearing through the tranſparent ſides of the web.
g The bottom of the web, anſwering to that of the wax-cell.

FIG. IV.

The Worm of the Bee, on the point of changing to to a Nymph, and ſtripped of its ſkin, the better to ſhew the infant parts of the future Bee, which are here repreſented as they appear through the microſcope, after extending them a little.

a a The antennæ, or horns.
b The proboſcis, with its parts.
c c The ſecond pair of joints belonging to, or forming, the proboſcis.
d d The firſt pair.
e e The firſt pair of legs, lying againſt the breaſt.
f f The ſecond pair of legs.
g g The third pair.
h h The greater wings.
i i The ſmaller wings.
k The abdominal wings.

FIG. V. and VI.

The Worm of the working Bee, changed to a Nymph, of its natural ſize and form, yet ſo as to exhibit its limbs, which are folded up in a moſt wonderful manner.

a a The head.
b b The greater eyes, one at each ſide of the head.
c c The antenna, or horns. *d* The proboſcis.
e e The wings. *f* The three pair of legs.
g The abdominal wings.

FIG. VII.

The Worm of a Female Bee, changed into a Nymph, ſhewing its parts diſpoſed in the ſame manner with the former.

FIG. VIII.

The Worm of a Male Bee, changed into a Nymph, differing externally from the two former Nymphs no otherwiſe than as the Male Bee itſelf differs from the Female Bee, and the working Bee.

FIG. IX.

The Nymph of the Bee viewed with the microſcope, diſplaying in a diſtinct manner all the parts of the encloſed inſect, and the beautiful manner in which they are laid up.

a The head, bloated with humours.
b b The eyes, projecting conſiderably.
c c The horns, or antennæ.
d The lip. *e e* The teeth, or jaw-bones.
f f The firſt pair of joints belonging to the proboſcis.

g g The next pair. *h* The proboſcis itſelf.
i i The firſt pair of legs.
k k Two tranſparent, ſtiff little parts, lying againſt the loweſt joints of the firſt pair of legs. Theſe little parts are not to be found as they remain in the ſkin it ſheds on quitting the Nymph ſtate.
l l The ſecond pair of legs.
m m The wings. *n n* The blade bones.
o o The laſt pair of legs.
p p The abdominal rings.
q The hinder parts of the body. The ſting projects a little in this place.
r Two little parts accompanying the ſting.
s The anus.

FIG. X.

The diſtribution of the pulmonary tubes through the wings, as they appear through the microſcope.

a The origin of the wings, where the pulmonary tubes are biggeſt.
b Ramifications and mutual anaſtomoſes or inoſculations of the ſaid tubes through the wing.
c The extremities of the ſaid tubes.

TAB. XXVI.

FIG. I.

The neſts or habitation of the Humble Bees.

a One part of the neſt, containing eighteen cells. *b* Another part, containing eight cells.
c A cell quite empty, and open.
d An irregular bit of wax placed againſt one of the cells, in which I found ſix eggs.
e An irregular bit of wax placed againſt one of the cells, in which I found twenty-three eggs.
g A part of the little cells that contained worms.
h A little Worm extracted from its cell, juſt as it was on the point of becoming a nymph.
i A large Worm of that kind, of which I found two in a cell that was ſhut up.
k A larger Worm, found by itſelf in one of the cells.
l A cell divided into two parts, in one of which I found two ſmaller Worms, and in the other two, a little bigger.
m A little worm of that kind, of which I found three in one cell.
n A little Worm of that kind, of which I found four in one cell.
o The eggs of theſe inſects faſtened or glewed by one of their ends, to the ſurface againſt which the parent lays them.

FIG. II.

Exhibiting the Lupus Alvearius, or Beehive Wolf, and the particulars of its hiſtory.

a The Vermicle, or Worm called the Beehive Wolf, by thoſe who feed them.
b A Butterfly of a pale gray, reſembling a moth, from which the Beehive Worm iſſues; after which it lays amongſt the honey-combs.
c c A hollow tubulated web, which the Worm Lupus, or Beehive Wolf, forms, and in which it runs about here and there, as in ſo many burrows.
d A ſmaller Butterfly, producing a ſmaller kind of Beehive Wolf.
e The web, which on the outſide appears rough and uneven with the Inſect's or Worm's excrements, and contains the Beehive Wolf-Worm, now full grown, and on the point of performing its mutation.
f The Chryſalis or Aurelia, into which the Beehive Wolf Worm is changed.

FIG. III.

The little Worm found in the Neſts of Wild Bees, and its mutations.

a The Worm itſelf. with ſix feet, and of a reddiſh colour.
b The Nymph, into which the ſaid Worm afterwards changes.
c A beautiful Beetle, which, within the ſpace of a year, iſſues from the ſaid Nymph, ſo as to make it plainly appear that neither the Nymph nor the Worm belonged to the tribe of Bees.

FIG. IV.

Another ſpecies of Wild Bees, repreſented a little bigger than nature.

FIG. V.

A third ſpecies of Wild Bee.

FIG. VI.

A fourth ſpecies of Wild Bee, having very long and very thick antennæ or horns.

FIG. VII.

A fifth ſpecies of Wild Bee.

FIG. VIII.

A ſixth ſpecies of Wild Bee.

FIG. IX.

A Hornet.

a a The Inſect's four wings.
b b The two ſharp nails with which the extremity of each leg is armed.
c The head, with its eyes in the form of a creſcent, horns, proboſcis, and teeth.
d Its formidable ſting.

FIG. X.

A Waſp of a middling ſize.

FIG. XI.

A Waſp of an unuſual form.

FIG. XII.

An Humble Bee of a middle ſize, having its belly ſurrounded with hairs of different colours.

FIG. XIII.

A tripilis Muſca, or three-haired Fly, being a kind of Pſeudophica.

FIG. XIV.

The Neſt of the ſmalleſt ſpecies of Waſps.

c c c Three integuments, or coats of the neſt.
d The body of the neſt, of which a piece is broken off, to ſhew the
e The hexogonal cells in which the eggs are hatched.

FIG. XV.

A Waſp's neſt, that I found ſticking to a nettle, compoſed of nothing but cells, built cloſe one againſt another, without any integument, or common covering.

TAB. XXVII

Repreſenting the hiſtory of the Naſicornis, or horned Beetle

FIG. I.

The Male.

a Its horn, which, properly ſpeaking, grows rather from the head than the noſe.
b Its mouth, ſeated in the breaſt, furniſhed on the upper part with three little teeth, of a ſubſtance between bone and horn, and without any perioſteum; theſe creatures differ from men and quadrupedes in this, that their bones do not lie hid within their bodies, but appear naked on the outſide of their fleſh, to which they ſerve as a defence and covering.
c The ſhells or ſheaths of the wings.
d A little triangular, horny bone, placed between the ſaid ſheaths, which it ſerves to keep cloſe to the body, and in the proper ſituation: this bone lies on the firſt ring of the abdomen.
e The edge or border of the ſheath, forming a kind of ornament.
f One of this Hornet's eyes.
g g Two antennæ or horns: thoſe of the male are bigger than thoſe of the female.
h A little horny bone, forming the third joint of one of the Hornet's ſix legs, which are all of them covered with coarſe hairs.
i The foot itſelf, conſiſting of five joints, the laſt of which is armed with two crooked nails.

FIG. II.

The female, ſcarce differing from the male in any thing but ſize, and her not having a horn.

a A ſmall prickle growing on the female's head, to ſupply as it were the want of a horn.
b The wings expanded under the ſheaths, and the ſheaths themſelves a little drawn in, by which means a better view is obtained of the little triangular bone, which ſerves to retain the ſheaths in their proper ſituation. Between theſe ſheaths there appear on the upper part of the fore or firſt rings of the abdomen, which in the male can only be ſeen in the lower part under the ſheaths.
c c Two joints in the rings themſelves, which they ſerve to fold, ſo as to make them fit under their ſheaths, that they may receive no harm, while the Hornet creeps under ground.

FIG. III.

The Eggs.

a Two larger eggs.
b Two ſmaller eggs, but of different ſizes.

FIG. IV.

The Worm.

a The Worm of the horned Beetle, called Coſſus, newly hatched. It here exhibits its very large head, two teeth, and three legs belonging to one ſide of the body.

FIG. V.

The Coſſus full grown,

a Beautiful wrinkles and folds, with which the ſkin is adorned.
b Nine reddiſh ſpots on one ſide of the body, having each of them a hole through which the Worm breathes, and ſupplies with air its pulmonary tubes.
c A ſpot like the former, belonging to the other ſide of the body, and placed on the firſt or ſecond ring of it
d One of the horns, which conſiſt each of five joints.
e e The teeth, or jaw bones.
f Two articulated briſtles, above which the lip appear ſeated between the teeth.
g Three of the inſect's ſix legs, each of which is compoſed of five joints, formed of a ſubſtance between bone and horn, beſides a ſingle nail; and which are moreover covered with hair.
h Some pulmonary tubes which appear through the extended out-ſkin of the thirteenth and fourteenth rings of the inſect's body.
i The extremity of the ſtraight gut forming the anus.

k k Hairs covering the body. I here repreſent but thoſe that grow on the back and abdomen, to avoid the neceſſity of making the figure bigger than nature.

FIG. VI.

The exuviæ, or caſt ſkins, and pulmonary tubes caſt off by the Coſſus.

a a a Nine twiſted little threads of the pulmonary tubes, appearing in one ſide of the caſt ſkin, rolled off from the body through the breathing holes, at the time the Worm undergoes this mutation; accordingly all their extremities lie in a direction towards the fore end of the body, as the ſkin at this time falls off in a contrary direction from the hinder end.

b b Two ſmaller branches of the pulmonary tubes, one at each ſide of the body. Tho' theſe branches do not perforate or paſs thro' the ſkin, nevertheleſs as they are faſtened to it, they come away at the ſame time. One of theſe branches is divided into ſome ſtill ſmaller ramifications; the other appears exactly in the condition, in which with the other nine it fell naturally from the body.

c c c c Some branches and ſmaller ramifications of the nine pulmonary tubes of the other ſide, a little folded out.

1 2 3 The ſkull, which at this time divides into three parts.

d d The caſt teeth, which are hollow.

e The caſt lip.

f f The horns, which are likewiſe renewed.

g g The two other remaining parts of the parted ſkull. They are hollow, and of a ſomewhat ſpherical form.

h Six openings in the ſkin, that formerly contained the new legs.

i The hinder part of the ſkin folded up.

FIG. VII.

The fibres ſerving to move the rings.

FIG. VIII.

The heart of the Coſſus.

a The heart reſembling a membranaceous tube.

b The narroweſt part of the heart, ſeated near the head.

c Two dilatations of the heart.

d That part of the heart, which lies within the laſt rings of the body, and is very ſlender.

FIG. IX.

The fat, compoſed of globules, like the grains of ſand.

FIG. X.

The fat examined by the Microſcope,

a a The tranſparent membranaceous foundation of the fat cell.

b b Some pulmonary tubes diſtributed through the fat.

c c Globular and oily particles of fat, which float, as it were, in other membranaceous, globular, and irregular particles, ſo as to make it probable that this fat conſiſts of bladders.

FIG. XI. and XII.

The ſtomach, and adjacent parts.

a a a a The diſſected ſkin of the Coſſus.

b The gullet. *c* The upper part of the ſtomach.

d d Appendages of the ſtomach, in the ſhape of teeth, ſeated about the upper end of the ſtomach, and divided both above and below, into rows.

1 2 The two upper rows in their natural ſituation. *Fig.* XII. *e.* All the ſix upper rows of the appendages, as well thoſe belonging to the upper, as thoſe belonging to the lower region are here exhibited, but as they appear when taken out of the body.

1 2 Two of the rows already exhibited, in an inverted ſituation, as they naturally lie with their points directed towards the inſect's head.

3 4 Two lower rows in the ſame direction.

5 6 The two laſt rows of the appendages, adhering to the lower region of the ſtomach, with their points directed backwards.

f A ſuture on the lower ſurface of the ſtomach, in ſome meaſure reſembling that of the peritonæum.

g Some other appendages of the ſtomach, lying lower down than thoſe already taken notice of, with their points directed backwards.

h The hinder part of the ſtomach.

i i The loweſt appendages, which appear as it were in the bottom of the ſtomach. Theſe appendages are directed towards the head.

k k k k The vaſa varicoſa, or the ſwollen guts of the ſtomach, placed on the upper and lower parts of it, and on each ſide, and forming a moſt beautiful appearance.

l The pylorus with the ſlender gut, which ſprings from the ſtomach. This part the antients call Ecphyſis.

m The colon.

n n Pulmonary tubes running from the laſt pair of breathing holes towards the ſtomach, and branching into a great many ramifications, that are diſtributed over the ſtomach, the colon, and the ſtraight gut.

o o o o The other ſixteen breathing holes, in their natural ſituation, as they appear thro' the ſkin.

p The ſtraight gut, diſplaced.

q A rough draught of the parts of the head.

TAB. XXVIII.

FIG. I.

The brain and ſpinal marrow of the Coſſus.

a The brain, with the four nerves that it produces.

b Two origins of the ſpinal marrow at ſome diſtance aſunder, but meeting lower to form one trunk.

d d d Nerves iſſuing from the ſpinal marrow.

FIG. II.

A recurrent nerve, as is appears through the microſcope.

a a The origins of the recurrent nerves, cut off in that place where they iſſue from the brain.

b b Recurring nerves, tending upwards; their aſcent may be ſeen on each ſide of the inſect's gullet.

c c Elegant inflections of the recurrent nerves.

d The firſt nodule formed by the recurrent nerves after their union.

e A recurrent nerve again changed to a ſingle one.

f The ſecond nodule of a a recurrent nerve.

g Small nerves branching from a recurrent nerve.

FIG. III.

The ſpinal marrow of a Silk-Worm when about to enter the Nymph ſtate, the better to ſhew the difference between its ſpinal marrow and that of the Coſſus. As likewiſe what little reaſon ſome people have to conſider every dilatation of the marrow as a diſtinct brain.

a The brain.

b b b 1 2 3, *&c.* The ſpinal marrow, conſiſting of twelve globules or nodules, which are formed as it were by the union of twelve pair of nerves iſſuing from the brain.

c c A pair of nerves running to the eyes.

d d A conſiderable part of nerves iſſuing from the firſt nodule of the marrow, and tending towards the muſcles of the head, teeth, and other parts. Every one of theſe nerves form by itſelf a beautiful nodule.

e e Two of theſe nodules.

f A pair of very fine nerves iſſuing from the brain, or origin of the ſpinal marrow.

g The recurrent nerves in their natural ſituation, with the two nodules belonging to them, and the nerves ariſing from the ſaid nodules.

h A pair of nerves ariſing from the firſt nodule of the marrow, and running towards the little bags that contain the juice of which the ſilk is compoſed, like a glutinous liquid. This pair of nerves ſerves perhaps to animate the moving and extruding fibres of the ſaid ſilk bags.

i i Two pair of elegant nodules, formed by nerves that proceed from the brain, and firſt nodule of the ſpinal marrow, and are diſtributed chiefly towards the muſcle of the head.

k k k k Four pair of nerves which iſſue from the very origins of the marrow, and by no means from its nodules. In my opinion the origin of all the other nerves is like this, as more particularly appears in the nerves of the Silk-Worm Butterfly, in which the ſubſtance forming the nodule is of a different nature from that of the ſpinal marrow, ſo that the whole is encloſed in the latter merely for the ſake of procuring it greater firmneſs.

In man, the origin of whoſe marrow conſiſts likewiſe of two parts, the nerves ariſe in like manner from the nervous part of the marrow, which is full of fibres, and after proceeding a little way beyond the ſaid nervous part, and growing ſomewhat longer, they every one of them unite to form ſuch nodules at different diſtances from their origin. The ſame diſpoſition is obſervable even in quadrupedes. On placing the warm marrow of theſe inſects on cold ſpring water, it hardens to a conſiderable degree, and very plainly exhibits its fibres, and the heterogeneous matter, of which it is formed. This circumſtance I have repreſented by a great many curious drawings, done after nature, in Dr. Slade's houſe, from a ſpinal marrow, publiſhed by Dr. Blaſius with his book of Commelyn. But this laſt gentleman added the deſcription. My name was not mentioned on this occaſion, becauſe ſome other Gentlemen, who aſſiſted me in the diſſection, not chooſing to have their names made publick, I thought it improper that mine ſhould.

It is likewiſe very remarkable, that in men and brutes, the pia mater, encloſing the medullary ſubſtance that iſſues like a fine filament from the marrow, in order to form a nerve, lies ſo cloſe and firm about the nerves, that it is ſcarce, if at all poſſible, to penetrate into its ramifications with the fineſt threads that glaſs can be drawn into. And as this narowneſs is ſtill increaſed by the medullary ſubſtance, it is eaſy to gueſs how ſubtile that matter muſt be, which flows through theſe and other nerves, and is only reſtrained by that very fine membrane called the pia mater, I therefore firmly believe, that this matter, called the animal ſpirits, is not to be gathered or contained by any veſſels, and is, for that reaſon, altogether inviſible.

But that theſe little nerves ſhould be in no danger of entangling one with another, or diſplaced, the Author of Nature has contrived that they ſhould form various nodules; and that each of them, at its origin, ſhould, in men, as well as beaſts, be connected by that delicate membrane, which forms the third coat of the brain, and is called, by us, Arachnorides, on account of its extreme fineneſs. The cavities of the ventricles of the brain are united together merely by means of the ſaid coat, which likewiſe ſerves to keep firm in their proper ſituation the arteries adhering to the bottom of the brain. As therefore the ventricles of the brain have no other coat to encloſe and connect them, but this very delicate one, which gives way to the ſlighteſt impreſſions, we may eaſily ſee, that the ſaid ventricles are by no means ſuited to contain the animal ſpirits, which no doubt are continually paſſing and repaſſing through the whole ſubſtance of the brain, marrow, and nerves, in order to contract the muſcles. It is therefore the pia mater alone that can be ſuppoſed to contain the animal ſpirits. But I abſolutely deny, that, as ſome people think, theſe ſpirits paſs in great quantities through the ſaid coat, as there are not to be found in the brain or origin of the marrow any ventricles; or any great quantity of ſpirits, that we may ſuppoſe to be driven backwards and forwards in ſuch a manner. Beſides what power ſhould drive them. There are no muſcles at hand for that purpoſe; and as to the opinion of ſome, who attribute ſuch a motion to the heart, experience ſufficiently proves, that the juices ſecreted from the blood move ſlower than the blood itſelf. It would be more agreeable to experience to ſuppoſe, that ſome juices are ſecreted from the blood into the nerves, in order to move the muſcles; nor would a great quantity of ſuch juices be neceſſary, as appears plainly in the caſe of the ſmalleſt tumours.

In Frogs, the Wray-fiſh, and other animals, after the nerves have been ſeparated ſome hours from the ſpinal marrow, and all motion has ceaſed in the muſcles, I can notwithſtanding reſtore the ſaid motion, by only any how irritating the nerves ſo cut off. And this makes me believe, that the blood, that continually flows through the arteries into the marrow and nerves, produces in the muſcles, by means of the nerves, ſuch a conſtant irritation, as muſt keep the muſcles in a ſtate of perpetual contraction. To explain the mechaniſm of this motion; The food we take in, after paſſing through the heart, increaſes our blood: the blood drives to the brain, irritates the muſcles to contraction, by ſecreting ſome few ſubtile particles, which are moved towards the nerves, and penetrate them. The muſcles will, in their turn, put their contents in motion, and thus a perpetual and uninterrupted motion muſt of courſe be produced in all the parts of the animal machine. It would certainly be worth while to demonſtrate, by a due courſe of experiments, theſe operations of the blood, ſpirits, nerves, and muſcles. What I have here ſaid of them is only by way of parentheſis, and therefore I think I have ſaid enough.

l l l l Some very beautiful inoſculations of the nerves.

m m m The reſt of the nerves iſſuing from the lower part of the medullary nodules.

n n n &c. Some parts of the ſpinal marrow, where its diviſions are not ſo conſpicious, as more particularly appears in three places near the breathing-hole, or reſpiratory points.

1 2 3, *&c.* Nine breathing-holes, which I here repreſented, to ſhew the ſituation of the ſpinal marrow, with reſpect to the annular inciſures of the body.

o In this place I have repreſented the ſpinal marrow with a greater cleft, than it really has, the better to ſhew the nerves *l l.*

The remaining part of this figure repreſents the genital parts of the Male Silk-Worm Butterfly.

p p Two branches of the laſt and greateſt pair of nerves, which branches, proceeding from the loweſt part of the marrow, are cleft near their extremities, and form a ſlit for the paſſage of the vaſa differentia *r r.*

q q The teſticles of the Silk-Worm Butterfly, already diſcernible in the Silk-Worm itſelf.

r r The vaſa differentia.

s s Places at which the ſaid veſſels run in a ſurpriſing manner through the nerves of the marrow. I leave others to judge whether or no this diſpoſition contributes to increaſe the titallation.

t A proſtata, or ſomething analagus to that glandule.

u u The ſaid bags, ſupplied with their ſeminal matter from two diſtinct tubes. Theſe bags are not only ſeparated from the vaſa differentia, but have not the leaſt communication with them.

x x The body of the penis, with a perforation from end to end for the paſſage of the ſeed.

y y Two nails or hooks growing near that part of the penis, which is of a ſubſtance between bone and horn. It is by means of theſe nails or hooks that the male fixes itſelf againſt the vulva of the female, and draws her towards him, the ſurer to penetrate her with his penis. The ſame contrivance appears in the horned Beetle, and other inſects.

z Part of the penis, conſiſting of a horny bone. The bone ſerves as a præputium or ſheath, from whoſe fore end the penis projects.

FIG. IV.

An oval neſt, hollowed out under ground by the Coſſus, in which it changes to a Nymph.

a a The earth in which the Coſſus had formed its oval neſt.

b The neſt itſelf.
c The Coſſus, changed into a Nymph.

FIG. V.

The changes viſible in the internal parts of the Coſſus, a little before its entering the nymph ſtate.

a The gullet as not yet altered, and paſſing through a cleft in the marrow, while the Coſſus continues in the Worm ſtate.
b b The ſtomach, with its appendages conſiderably contracted.
d d d The vaſa varicoſa ſeparated from the upper and lower parts of the ſtomach, and out of their natural ſituation.
e The inſertion of theſe veſſels; for behind the pylorus they open by four tubes into an ecphyſis.
f f The colon, almoſt of its former ſize, owing to the contents of the ſtomach and ſmall gut being fallen into it.
g Cells of the colon, with its ligament in the middle.
h The ſtraight gut.
i i The vaſa varicoſa folded and coiled in a moſt ſurpriſing and beautiful manner againſt each ſide of the ſtraight gut.
k A rough draft of the Worm's head.

FIG. VI. VII. and VIII.

A front view of the Nymph of the Coſſus, and all its parts, ſlightly expreſſed by the graver, and deſcribed by lines only, the better to ſhew its parts. The eighth figure repreſents the lower parts of the Coſſus's head, that the changes it undergoes may be the better comprehended.

a The horn growing on the noſe.
b The root of the ſaid horn; which in the Beetle is covered on its lower part with ſome ſtiff red hairs. This part grows in the noſe of the Coſſus.
c c Two ſpherical tubercles, being the remains of the Coſſus's teeth *d d*. Fig. VIII. And therefore theſe teeth are four times ſmaller in the Beetle, than they were in the Coſſus.
d d The teeth of the Coſſus.
e e Two pair of tubercles like the former, being the remains of the Coſſus's horns *f f* Theſe tubercles are of quite another form in the Beetle.
f f The Coſſus's two horns.
g g Two tubercles of a more oval form, grown from the articulated briſtles of the Coſſus *h h*, and afterwards viſible in the Beetle itſelf.
h h The articulated briſtles of the Coſſus.
i Three beautiful globules placed in the middle, and growing from the particles of the Coſſus marked *k*. Theſe globules are likewiſe of another figure in the Beetle.
k The four briſtles of the Coſſus, already taken notice of.
l The greateſt ſpherical diviſion of the Nymph, which in the Beetle conſiſts of a horny bone, and is covered with hair on each ſide.
m m The breaſt bone.
1 1 The firſt pair of legs.
2 2 The ſecond pair.
3 3 The third pair, with its joints
n n The ſheaths of the wings.
o o A ſmall portion of the wings themſelves.
p p The abdominal rings.
q The two ſhield-like parts of the anus.

FIG. IX.

A back view of the Coſſus, ſhewing the fourteen annular inciſions of its body, and the tranſpoſition of its breathing-holes.

1 The firſt ring of the body, now armed with a horn on the head.
2 1 The ſecond ring, in which the firſt pair of breathing-holes is ſeated under the fore legs, one at each ſide of the thorax.
3 4 The third and fourth ring, which form but one ring, and may be ſaid to conſtitute the hinder part of the thorax.
5 2 The fifth ring, in which the ſecond pair of breathing-holes is ſeated under the wings, one at each ſide.
6 3 The ſixth ring, in which the third pair of breathing-holes externally appears, one at a ſide, on the borders of the belly.
7 4 The ſeventh ring, and fourth breathing-hole.
8 5 The eighth ring, and fifth breathing-hole.
9 6 } The ninth and tenth ring, and ſixth
and } and ſeventh breathing-holes, all very
10 7 } diſtinct in the Coſſus, but in the Beetle
pretty cloſely united.
10 8 } The eleventh, twelfth, and thirteenth
12 9 } rings, which now in a manner form
13 } but one ring. The eighth pair of
breathing-holes, placed on the eleventh ring, is almoſt cloſed up in the Nymph. And the ninth pair, which in the Coſſus appeared in the twelfth ring, is no longer to be ſeen in its Nymph.
14 The fourteenth ring, viſible only in the belly, between the two ſhield-like parts. I here only mark its ſituation.

TAB. XXIX.

FIG. I.

The Caterpillar of the ſwift Butterfly.

a Its head, and ſome of the hairs growing on its forehead or forepart; likewiſe its two teeth.
b Its breaſt. *c* Its belly.
d Its tail, in which are ſeen its two hinder legs.
e The extremity of the tail, ending in a point. Neither the breathing-holes, the fore, or middle part, are to be ſeen in this Caterpillar,

pillar, as I have repreſented it lying on its belly.

FIG. II.

The Chryſalis or Aurelia of the ſwift Butterfly, belonging to the ſecond mode of the third order or claſs.

a The eye.

b The proboſcis, beautifully bent back towards the belly.

c The horns and legs, ſtretched over the body.

d The wing belonging to one ſide.

e e The rings of the breaſt, and of the abdomen.

FIG. III.

The ſwift Butterfly.

a a The eyes.

b b The antennæ or horns, growing above the eyes.

c The proboſcis, conſiſting of a double tube, by means of which this inſect conſtantly ſips up its food, while flying. It is to be noted that the great length of this curious organ is contrived by Nature, that the inſect ſhould take its food without being obliged to fly too near the flowers, which might injure its wings.

d The extremity of the proboſcis, coiled up by means of ſome minute muſcles. Thus the Butterfly can gather up this part into a little compaſs, and hide it between the forks.

e A ſide view of part of the forks. The forks are two particles covered with hairs, formed like a feather.

f The tail, by means of which the inſect, when on the wing, ſhapes its courſe; ſo that its flight is ſteddier than that of other Butterflies. The reſt appears behind the head and breaſt, and the abdomen, which is beautifully adorned with hairs, made in form of feathers, and of changeable colours.

g g The upper wings, which are the largeſt.

h h The lower wings. All the four wings are curiouſly ornamented with hairs and ſcales. And theſe ornaments, by containing a great deal of air, make the Butterfly lighter than it otherwiſe would be, and conſequently the fitter for flying.

FIG. IV.

The Sicarius, or Aſſaſſin Worm, an aquatic inſect.

a a Its ſix hairy feet.

b. Its hairy tail, furniſhed, as it were with two oars, by means of which the Worm can float on the ſurface of the water.

c c Sharp and crooked teeth with which this inſect kills other inſects for its food, and ſucks up their blood.

d d Eight of the inſects twelve eyes, of which ſix are at one ſide of the head, and ſix at the other.

e e e Four ariculated briſtles growing under, and between the teeth.

f f Two longer briſtles, which may be conſidered as the inſects horns.

g Six breathing holes. This Worm has ſixteen.

FIG. V.

A tooth of the Sicarius, or Aſſaſſin Worm, viewed with the microſcope.

a The point of the tooth, ſharp, and crooked.

b A ſharp ridge on the internal ſurface of the the tooth.

c The convexity of the external ſurface.

d An oblong aperture, or ſlit, through which that inſect ſucks its food.

FIG. VI.

The breathing holes of the Beetle, in their natural ſituation; as likewiſe the rings of the body, which may be taken from the figure of the Nymph already exhibited.

a 1 The firſt breathing hole placed obliquely backwards in the breaſt bone, upon the ſecond ring.

b 2 The ſecond breathing hole, ſituated higher under the wings in the fifth ring, and in an oblique direction to the firſt breathing hole.

c 3 The third hole, ſituated a little higher up on the edge of the abdomen, and in the ſixth ring,

d 4 The fourth ſtill a little higher up on the ſeventh ring.

e 5 The fifth higher up again in the eighth ring.

f 6 *g* 7 *h* 8 The ſixth, ſeventh, and eighth holes, conſiderably ſmaller than the preceeding ones. They lie on the ninth, tenth, and eleventh rings.

i 9 The ninth hole, that appeared in the twelfth ring, now quite cloſed up.

FIG. VII. and VIII.

The eyes, optic nerves, and brain of the Beetle.

a The eye juſt diveſted of the cornea, and the uvea, ſo as to ſhew its inveſted pyramidal fibres.

b A ſnow white fibrous coat of the eye, in which all the pyramidal fibres terminate.

c The optic nerve ſeparated from the inſide of the ſaid coat's cavity.

d The dark colour of the ſaid coat. There are in this place a great many ramifications of the pulmonary tubes, of which I have repreſented three branches.

e The manner in which the pulmonary tubes run along the inverted pyramidal fibres in a a ſerpentine courſe towards the cornea, in the eye of a live Beetle. I have repreſented theſe pulmonary piſtules, ſomewhat thicker than they really are, that they may appear the more diſtinct.

f f Two horny bones growing on the ſkull, over the eye, which they in a manner divide.

g An expanſion of the ſkull, of a ſubſtance between bone and horn, commonly called the noſe-horn, with its rugged ſurface.

h A ſuperficial diviſion of that part of the eye, which lies within the ſkull; this diviſion is formed by the upper projections of the ſkull.

i The brain, conſiſting, as it were, of two united globules.

k Pulmonary tubes of the dura mater, and optic nerves.

l l The fineſt parts of the optic nerves, juſt at their iſſuing from the brain.

m m The ſame nerves grown bigger.

n n The ſame grown ſmaller.

o o The ſame again increaſed, on their approaching the eyes.

p p The origin of the ſpinal marrow, cut off in that part where it forms a ſlit for the paſſage of the gullet.

FIG. IX.

The Pulmonary tubes, with their veſicles in the horned Beetle.

a a Diſtended veſicles of the pulmonary tubes, of which I here give an entire branch bigger than nature.

b b Tubes and their literal branches, ſpringing from the upper part of the veſicles.

c c Some tubes iſſuing from the ſides of the ſaid veſicles.

FIG. X.

A pulmonary branch and its veſicle, viewed with the microſcope.

a a Rings that compoſe the tube, of a ſubſtance between bone and horn.

b The ſtructure of theſe rings, which is ſuch as to make it probable they are formed by a concretion of ſpherical particles.

c c Some places, in which the convolutions, compoſing the rings are terminated, and ſucceeded by new ones.

d d Membranes binding the rings together; in theſe membranes there appear ſpherical particles, of which they are in a manner compoſed.

e e Some ſmaller rings at the top and bottom, of the pulmonary veſicle.

f f The ſtructure of the pulmonary veſicle itſelf. It is of a white membranaceous ſubſtance, compoſed of an infinite number of minute globules, which on account of their convex ſurfaces give this part, as often as the light ſhines on it, a white colour, though without any reſplendency.

TAB. XXX.

FIG. I.

Viſiculæ pneumaticæ, or breathing, or pulmonary veſicles, that appear between the two plates of the ſheath covering the wings.

a a The two largeſt branches of the trachea, which appear through the ſaid plates, on holding them to the light, and examining them with the microſcope in that ſituation.

b b b Pulmonary tubes iſſuing from the branches *a a*, with their veſicles.

c c c Pulmonary tubes iſſuing from the ſaid veſicles, and again forming other veſicles and tubes, *&c.*

FIG. II.

The firſt ſpecies of an Exotick, Rhinoceros, or horned Beetle.

a Its eye, from which iſſue the projecting part of the ſkull.

b An excreſcence of the ſkull, forming a kind of horn, in the middle of which there appears a tubercle with a ſharp point, and a ſingle cleft at its end.

c The breaſt bone projecting on the fore part in a ſingle tube, which terminates in two teeth.

d d The two lids or covers of the wings, between which there lies on the inſect's back about its breaſt a triangular horny bone. This bone keeps the lids or covers when ſhut from running one over the other.

e The abdominal rings, in which are the two breathing holes of the Beetle, that are almoſt cloſed up; I have left them unſhaded, that they may appear the plainer.

f f f The three legs belonging to one ſide, with their joints, nails, and hair. The breaſt-bone of this inſect, and likewiſe the projecting part of the ſaid bone, and the noſe-horn, are all of a deep brown inclining to black; but the ſheaths of the wings are ſomewhat paler, and near to a light red. The legs are black.

FIG. III.

A ſecond ſpecies of the horned Beetle, which may be very properly called the flying Elephant.

a The eye belonging to one ſide of its head, in regard to which it plainly appears, that it is covered like that of the Dutch horned Beetle, by a projecting proceſſus of the ſkull, of a ſubſtance between bone and horn, and that it is likewiſe united with the ſaid proceſs.

b Another projection of the breaſt bone, of the ſame ſubſtance with that of the ſkull. This projection covers the eye too, but is by no means united with it; for the eye is only hid by the ſaid projection, which ſerves as an eyelid, and moves backwards and forforwards over the eye, as the Beetle moves its head.

c Some ornaments of the ſkull.

d The noſe-horn of the ſkull, reſembling the proboſcis of an Elephant.

e A tubercle, in form of a tooth, growing near the end of the noſe-horn, which is moreover cleft in the middle; but as this is a ſide view of the inſect, the ſaid cleft cannot be ſeen.

f The breaſt bone.

g g Two ſharp prominent forks, or teeth of the breaſt-bone, in regard to which I conſider this inſect as having ſome reſemblance to an Elephant.

h The lids that cover the wings.

i The ſecond joint of the legs.

k The third joint.

l The fourth joint, or the foot, with its joints, hairs and nails.

As all theſe parts are compoſed of a ſolid horny bone, the muſcles are encloſed by them, whereas on the contrary in men and quadrupedes, the bones lie within the fleſh. This Beetle is very black, but ſhining withall, like poliſhed ebony, ſo as to afford a very pleaſing ſpectacle, eſpecially as its colour has a reddiſh caſt.

F I G. IV.

A third ſpecies of the horned Beetle.

a One of its eyes. *b* One of its horns.

c Its noſe-horn.

d d The breaſt-bone, and its projections.

e e The ſheaths of the wings. All the parts are gray, owing to an infinite number of ſmall hairs, that grow on them, the noſe-horn, and projections of the breaſt-bone excepted: But the ground of the horny bone, on which theſe hairs grow, is black, as is likewiſe the horny bone of the foot, whoſe hairs do not grow ſo cloſe, as thoſe covering the other parts.

F I G. V.

The breaſt-bone of a fourth ſpecies of Beetles.

a Some ornaments of this part, which is compoſed of a ſubſtance between horn and bone.

b A thick expanſion of the breaſt-bone.

c Its two blunt ends.

d Some hairs growing on the part that unites the head and thorax. Theſe hairs facilitate the motion of the head.

e Some projections of the ſkull.

f The noſe-horn, with its teeth.

g The horn, and one of the eyes.

F I G. VI.

A fifth ſpecies of a horned Beetle.

a Its eye.

b The noſe-horn, growing out of the ſkull, crooked and blunt.

c The firſt proceſſus of the breaſt-bone.

d The ſecond.

e The third. All theſe are only the limbs belonging to one ſide.

f A little prominent border, which is turned in, and entirely ſurrounds the breaſt-bone; it is found in every ſpecies of horned Beetles. Lower down, and more forward than the ſaid border, are to be ſeen thoſe ornaments of a horny bone, which are covered with looſe hairs.

g g A ſingle joint of the legs; the remaining parts may be conceived from the other figures.

F I G. VII.

Part of the heart of the Dutch horned Beetle.

a a Some broader parts of it.

b b Some narrower parts.

F I G. VIII. and IX.

The genital parts of the male horned Beetle.

a The part forming, as it were, the ſheath or foreſkin of the penis; this part is a horny bone.

b Two horny bones, or nails of the penis, by means of which the male, in copulation, fixes its penis into the vulva of the Female.

c The thick nervous part of the penis.

d The body or root of the penis.

e e The vaſa differentia, bigger in the middle than at the extremities.

f One of the teſticles quite unfolded, or laid open, in order to ſhew thoroughly the teſticulary veſſels.

g The extremity of the ſaid teſticulary veſſel. This veſſel is cloſed.

h The other teſticle, almoſt in its natural ſituation.

i The blind extremity of the teſticulary veſſel laid bare.

k k Seminal bags.

l l Two ſlender curled tubes, in which the ſaid bags terminate; and which terminate themſelves at each ſide into ſix other tubes.

m m Twelve moſt beautiful glands, ſix at a ſide, which are united with the ſaid twelve tubes, and ſend their ſeed to the penis by the ſeminal bags.

n The upper part of theſe glands, which is flattiſh.

o The lower part, which is globular.

p The lower ſide of the ſaid globular part, ſomewhat magnified, ſo as to ſhew in what what manner it is united with the tube of the ſeed-bag. This part contains a limpid ſeminal matter.

q A ſubſtance ſurrounding the ſeminal matter, which reſembles the white of an egg.

FIG. X.

The ovary of a Female, and its parts.

a The head of the female, ſeparated from the body.
b The gullet and ſtomach.
c The inteſtines.
d The exitus, or extremity of the inteſtines.
e e The ovary, conſiſting of twelve oviducts, ſix at a ſide, and ſtill containing eggs of different ſizes, or in which there moreover appear eggs of different ſizes.
f The vulva.
g A bag, ſhaped like a pear, opening into the vagina of the uterus.
h A blind veſſel, which in the inſect appeared like a tranſparent lymphatic veſſel.
i Another particle, communicating with that laſt mentioned, and containing a hard white ſubſtance.
k k k k Pulmonary tubes, and veſicles, diſtributed in great numbers amongſt the foregoing parts.
l A conſiderable branch of theſe tubes and veſicles, running at one end of the common ovary duct.
m Some other ſmaller branches belonging to the ſtomach and inteſtines.

TAB. XXXI.

The Hiſtory of the Arboreſcent Flea.

FIG. I.

The arboreſcent Flea.

a The aquatic aboreſcent Flea, a little bigger than nature.

FIG. II.

A ſide view of the ſaid Inſect, taken with a microſcope.

a One of the eyes, ſituated at one ſide of the ſnout.
b b Its branching arms, iſſuing from a ſingle trunk. Each of theſe branches terminates in two branches, which are again divided into joints and lateral hairs.
c The inſect's ſharp ſnout, with which it ſucks its prey.
d Its ſcaly ſkin, with an opening in it, through which it can thruſt out its body and tail.
e The tail, or extremity of the body, in which there appears an inteſtine through the tranſparent ſurrounding parts; the feet are to be ſeen in the ſame manner on the fore part of the body, near the opening in the ſkin juſt now mentioned.
f The extreme point of the rhomboibal ſhell, that covers the body.
h Tranſparent eggs, which lie on the fore part of the inſect, upon its pellucid body, with which they move backwards and forwards.

FIG. III.

A more front view of the arboreſcent Flea, with the opening in its ſkin.

a An eye. *b b* The branching arms.
c The ſnout.
d The ſlit, or opening in the ſkin, repreſented in its natural condition, but ſomewhat on the fore part, in order to exhibit the legs now projecting beyond it.
e f The tail, and its hairs, a little more thruſt out from under the ſaid opening.
g The ſharp point, or extremity of the inſect's ſcaly ſkin.
h That part of the body, in which the eggs lie.

A ſhort Hiſtory of the Gnat.

FIG. IV.

The Worm, which turns to a Gnat, of its natural ſize, viewed in different ſituations.

FIG. V.

The ſame Worm viewed with the microſcope, ſo as to ſhew its thorax and belly, and in what manner it can ſuſpend itſelf on the ſurface of the water, by means of the appendages of its tail.

a a The eye. *b b* The antennæ, or horns.
c The mouth, with its hairy parts, and articulated briſtles.
d d The thorax, with its hairs and diviſions. On diſſecting this Worm, feet are found laid up under the ſaid regular diviſions.
e e Eight diviſions of the belly, with its briſtly hairs.
f The tail.
g An appendix to the tail, through which appendix there appear two pulmonary tubes, through which the inſect breathes.
h Black ſpots, hairs, and little hollows on the extremity of the ſaid appendage. It is by means of theſe the Worm ſuſpends itſelf on the ſurface of the water
i Bubbles of air, diſcharged by the Worm from the appendage of its tail.

k k The

k k The two main trunks of the pulmonary tubes, ſhewing themſelves through the belly. Theſe trunks have their mouths in the appendage of the Worm's tail.
l The anus diſcharging ſome excrements.
m Excrements diſſolving in the water.
n A little tranſparent inteſtine, ſhewing in what manner the excrements are extruded.

FIG. VI.

The great Worm changed to a Nymph, of its natural ſize, in two different ſituations.

FIG. VII. and VIII.

Two repreſentations of the ſaid Nymph ſomewhat magnified, One of theſe repreſentations conſiſts of nothing but outlines, the better to exhibit the parts of the inſect, which it is intended to repreſent.

a One of the eyes on the ſide of the head. The head itſelf at this time lies higher up.
b One of the two antennæ. divided into black joints.
c A ſting, or prickle, with its ſharp point lying between the wings.
d d d d The legs; the hinder ones coiled up in a very ſurpriſing manner, and lying for the moſt part under the wings, through which however, thoſe belonging to one ſide ſhew themſelves in this figure.
e e One of the wings.
f f f Eight rings of the body.
g g A beautiful edging belonging to the belly.
h The tail, now hanging down, with its rowing fins.
i i The antennæ of the Worm, altered by caſting a ſkin. It is by means of theſe antennæ, that the Nymph now hangs by its head on the ſurface of the water, and in this ſituation breathes, and is enabled to perform its mutation with the greater facility.

TAB. XXXII.

FIG. I.

The male Gnat, of its natural ſize.

FIG. II.

The male Gnat viewed by the microſcope.

a a The eyes, reſembling a net.
b b The antennæ, much more beautiful than thoſe of the female.
c c One pair of the antennæ, or articulated briſtles. each of which conſiſts of three joints.
d The external ſheaths of the ſting.
e The ſting itſelf, or one of the five ſtings projecting beyond the ſheath.
f f f f The Gnat's ſix legs, conſiſting each of ſeven joints.
g g g g Sharp, ſcaly, feathers growing on the two wings.
h h Two little hammers, againſt which the Gnat ſtrikes its wings, and ſo makes a buzzing noiſe
i i The thorax, covered with ſtiff hairs.
k k The belly, conſiſting of eight rings, as in the Worm.

FIG. III.

The ſtings of the Gnat, and their internal ſheath, or horny channel.

a The external ſheath of the ſting, cut off near the head, and ſeparated from the ſtings, and their channel.
b The internal tubulated ſheath, or channel, containing five ſtings. The blood flows in this channel along or amongſt the ſtings. There are beſides in here two drops of a tranſparent liquor or humour, which perhaps is the poiſon ſaliva that produces the the tumour, in the wounded ſkin.
c c The very ſlender ſtings, extracted from the ſaid channel.
d d d Three thicker ſtings, pulled likewiſe out of the ſaid channel.
e The neck of the Gnat ſeparated from its body.
f The head.
g g The eyes of a reticulated form.
h h The horns cut off.
i i A pair of articulated briſtles cut off likewiſe.

FIG. IV.

The head, and ſting of the female Gnat.

a a The antennæ, or horns, which differ conſiderably from thoſe of the male.
b b The ſhorter articulated briſtles.
c The external ſheath of the ſting.

FIG. V.

The female Gnat of its natural ſize.

TAB. XXXIII.

Which exhibits the nocturnal Butterfly or Moth.

No. I. The Worm or Caterpillar of the nocturnal Butterfly, ſticking in its firſt coat or ſkin, and of its natural ſize.
II. The hardened ſhell of the egg, divided into two parts, as quitted by the Worm.
III. The Caterpillar itſelf, having attained its full ſize, remarkable on account of its wonderful form.
a Four little bundles of hair, behind the head, like ſo many cloaths bruſhes, clipt even at the tops; they are of a white colour, inclining to yellow, and ſet along the back.
b b Two other bundles of black hairs of unequal lengths, placed about the fore part of the head, and which appear like horns.

c c Two other feathers, like bundles of hairs, placed on each ſide of the breaſt like oars.
d d Two more, like the firſt, but not ſo beautiful; of a yellowiſh white.
e e Shorter feathers like hairs, placed all over the ſkin, and interſperſed with other longer ones.
f The feather-like ornamented tail.
IV. The ſame Caterpillar wound up in its web, ſhortly to undergo its change.
a a a The web, in which the Caterpillar has ſettled itſelf.
b The third and fourth ring ſwelled by the increaſe of the limbs within the Butterfly.
V. The ſame Caterpillar changed into a Chryſalis, or Aurelia, which in a little time is to become a male Butterfly, the limbs of the Butterfly that is by and by to be produced, are now viſible, tho' obſcurely.
VI. The male Butterfly produced from the former Chryſalis, in which may be ſeen
a a Its elegant horns. *b* Its ſmall body.
c c Its large wings, which are wanting in the female.

FIG. I.

The egg of the nocturnal Butterfly, ſhewn in No. I. *in its natural ſize, is here repreſented as magnified.*

FIG. II.

The egg, broken open by the inſect that ſtuck in it, repreſented as magnified; which was ſhewn of its natural ſize, No. II.

FIG. III.

The web quitted by the Catepillar, with the perforation it makes when about to be changed into a Butterfly; ſhewing how the eggs are glued in it, which are laid by the female Butterfly, which in like manner are afterwards to produce Caterpillars,

FIG. IV.

The Chryſalis of No. V. *repreſented, exhibiting all the external parts of the future male Butterfly: namely,*

a The two eyes in the head, under which ſtretched againſt the thorax is diſcerned the proboſcis or trunk.
b The antennæ, or horns, removed from their natural ſituation.
c c The ſix legs, alſo removed out of their proper place, that they may be the more eaſily viewed.
d d Two pair of wings.
e The wings of the abdomen.

FIG. V.

The Chryſalis of the female Butterfly, exhibiting again all its limbs and parts; as conſtructed in their natural ſituation.

FIG. VI.

The female nocturnal Butterfly, repreſented No. IV. *but far more imperfect in its limbs and parts than the male.*

a a Its two leſs elegant horns.
b The thick and diſtended body.
c c The four ſhort wings, or which may be rather called imperfect rudiments of wings.

FIG. VII.

The female, with her belly diſtended with eggs.

a The ſkin upon the back cut open and turned backwards, to ſhew the great number of eggs with which the belly is filled.

TAB. XXXIV.

The Hiſtory of Day-Butterflies.

FIG. I.

The Caterpillar from which the common Dutch day Butterfly is produced.

a Its external form, which is as it were ſet thick with prickles.
b Three of the foremoſt of its ſix legs.
c Four of the middlemoſt hinder legs.
d The two hinder legs.

FIG. II.

The Caterpillar magnified, exhibiting its thirteen annular diviſions.

1. The firſt annular diviſion or ring, conſtituting the head, in which
a a On each ſide are ſix eyes.
b b The antennæ or horns.
c c The teeth, placed under and near the lip.
d The little prominent particles, the middle moſt of which is formed like a papilla or nipple.
2. Another annular diviſion, with its briſtly hairs, which is called the firſt point of reſpiration, or breathing hole.
e Another of the firſt pair of legs, with its joints, having a crooked claw at the extremity.
3 4 The third and fourth ring, which have no breathing holes. The third ring, with the two larger ones alſo is beſet with ſmall prickles, of which only thoſe in the fourth are repreſented.
f Another of the ſecond pair of legs joined under the third ring.

g Another of the third pair of legs, joined under the fourth ring.

5. The fifth ring, on the other ſide of which there appear three prickly hairs.

h A prickly hair placed in the middle of the Caterpillar's body, like that which is placed on each of the twelve rings.

i The firſt and largeſt prickly hair, placed on the other ſide of the body; under and near which is ſeen a ſecond, and under it another breathing hole.

k A third prickly hair under the belly.

6 The ſixth ring, formed like the fifth, containing the third breathing hole.

7 8 9 10 Theſe rings are conſtructed in the ſame manner with the two former, in which appear the fourth, fifth, ſixth, and ſeventh breathing holes.

l l l l Four of the middlemoſt legs, together with their fleſhy articulations and crooked claws; joined in the bending part of the body, each with its ring.

11 The eleventh ring, formed like the former, in which is placed another of the eighth pair of breathing holes.

12 The twelfth ring, differing from the reſt in the number of its prickly hairs. The reſt of the nine breathing holes above it, are ſeen placed in this ſide of the body.

13 The thirteenth ring, adorned at leaſt with two prickly hairs.

m m The tail and the laſt pair of legs, placed in the extremity of it.

FIG. III.

The kidney-like little parts.

a a The diviſions which appear on the ſurface of theſe kidney-like parts.

FIG. IV.

The ſtomach, and its parts.

a The gullet, which runs naturally through a ſlit in the ſpinal marrow.

b b b b Some pulmonary tubes diſperſed over the ſtomach.

c c A tendinous ligament of the ſtomach.

d d d Muſcular tranſparent fibres of the ſtomach.

e e The vaſa varicoſa, or ſwollen veſſels, which are the cloſed inteſtines, conſtituting, as it were, twelve little inteſtines.

f f The place, in which theſe inteſtines, below the pylorus, are produced from the inteſtine next the ſtomach.

g g The manner in which the ſame is bent into ſix little tubes, and turned back towards the ſtraight gut, againſt which they are folded and curled.

h h Their windings and foldings,

i One of the thick inteſtines, in which the excrements receive their form; ſo that it is not unlike the colon.

k The ſtraight gut.

FIG. V.

Two veſſels hitherto unknown, which lie in folds near the ſtomach

a a Two tubes, which might very well paſs for ſilk bags.

b b The origin of theſe tubes, aſcending towards the brain; they are very narrow in this place.

c Swellings in theſe tubes.

d Their ſharp extremities, inſerted lower down near the blind guts.

FIG. VI.

The heart.

a a The hollow channel of the heart.

b b b, &c. Muſcles ſituated on each ſide of the heart, which they ſerve to dilate.

FIG. VII.

The brain and ſpinal marrow.

a The brain. *b b* Origin of the ſpinal marrow,

c The firſt nodule of the ſpinal marrow.

d d Two pair of nerves, ariſing immediately from the ſpinal marrow, which produces three pair more in the ſame manner.

e The ſecond nodule of the ſpinal marrow.

f The fourth and greateſt cleft or ſlit of the ſpinal marrow, below the third nodule.

g h The fourth and fifth nodules, with the ſingle nerves ſpringing from them.

i k l m n The ſixth, ſeventh, eighth, ninth, and tenth nodules of the ſpinal marrow, with the four nerves iſſuing from each nodule.

e The eleventh and laſt nodule of the ſpinal marrow, with the nerves that it produces,

TAB. XXXV.

FIG. I.

The web formed by the Caterpillar, when about to enter the Nymph ſtate.

a The Caterpillar's web, in which it fixes the nails of its hinder feet, and ſo remains ſuſpended head downwards.

b The third and fourth rings of the thorax, conſiderably diſtended by the blood and air, that dilate the latent wings and legs.

c Eight intermediate legs, which loſe their ſkins by degrees, and are at length ſlipt off towards the tail.

d The firſt order of legs, which are likewiſe about to ſhed their ſkins, and roll off one over another.

FIG. II.

The limbs of the future Butterfly, that grew out of ſight under the preſent inſect's ſkin.

a a Its two antennæ or horns.
b b The two ſhanks of the proboſcis.
c c Parts like forks.
d d The eyes.
e e The upper and lower pair of wings, between which are to be ſeen the legs growing from the thorax.
f f The rings of the body. *g* The tail.

FIG. III.

The natural diſpoſition of ſome of the latent limbs repreſented by the laſt figure, as appears through the microſcope.

a a The place where the horns or antennæ are jointed with the head, and from thence are regularly turned back, and folded in a ſerpentine manner.
b b The two ſhanks of the proboſcis, diſplaced a little from their natural ſituation.
c c The forky particles in their natural ſituation.
d d The eyes in their natural ſituation.
e A portion of the ſkin, that lay over the middle of the ſkull, which is in this place removed.
f f The root of the proboſcis.
g The forks, between which the inſect, when become a Butterfly, curls up its proboſcis.

FIG. IV.

The Caterpillar beginning to ſhed its ſkin.

a a The eight intermediate legs rolled off towards the tail, and ſhedding their ſkins.
b The ſix fore feet, ſeparating from each other, and ſlipping forwards.
c The ſkull divided into three parts, the middlemoſt of which is here repreſented.
d Another portion of the divided ſkull.
e The third portion.
f f The forky particles, which are the parts of the future Butterfly, that appear firſt.

FIG. V.

The Caterpillar in greater forwardneſs towards the Chryſalis ſtate.

a a The eight intermediate legs now driven higher towards the tail.
b Four of the fore pair of legs rolled off as far as the middle of the body.
c d The forky particles entirely diveſted of their ſkin; and the divided ſkull; and the firſt pair of the ſix fore legs rolled off higher upon the body.

FIG. VI.

The Caterpillar after it has quite thrown off its ſkin; ſo as to acquire the name of Chryſalis.

a The wings, horns, proboſcis, and legs, all of them extended, and of another form.
b The rings of the abdomen ſtripped of its ſkin: Theſe are now more compreſſed towards each other than heretofore. It here appears in what manner the Chryſalis, by means of the nails in its tail, continues ſuſpended by its web.

FIG. VII.

All the parts or limbs juſt now mentioned, as they appear through the microſcope.

a a The forky particles, which are no longer to be ſeen in the Butterfly. The third figure exhibits them under the letters *c c*, in their natural ſituation.
b The middle portion of the head, which heretofore lay under the ſkull, and is repreſented in the laſt mentioned third figure, under the letter *e*.
c c The root of the proboſcis repreſented in the ſame place under the letters *f f*.
d d The proboſcis itſelf denoted by the letters *b b*.
e The extremity of the proboſcis ſo much extended, as to reach the rings of the abdomen, and placed between the antennæ.
f f The firſt pair of legs.
g g The ſecond pair.
h h The antennæ or horns, whoſe origins or rudiments are exhibited by the third figure under the letters *a a*.
i i Their extreme ends, which are very thick.
k k The eyes, under which the horns lie bent. Theſe eyes are repreſented by the letters *d d* of the third figure.
l l l l The wings placed in each ſide of the body.
m m The nervous diviſions of the wings. Theſe diviſions are in reality no more than pulmonary tubes.
n n The rings of the abdomen cloſed and folded one over another.
o o Some prickly hairs like papillæ, diveſted likewiſe of their ſkins and ſeated on the inſect's back, from which they project a little. More forwards may likewiſe be ſeen four breathing holes.
p The tail freed from its ſkin, as likewiſe the anus.
q The nails of the tail, and the manner in the inſect uſes them to faſten itſelf to the web.

FIG. VIII.

The Chryſalis lying on its back.

FIG. IX.

FIG. IX.

The colour of the upper and largeſt pair of the future Butterfly's wings, as they very plainly appear through the tranſparent ſkin of the Chryſalis.

FIG. X.

The caſt ſkin of the Chryſalis, dividing into four ſegments.

a The firſt part of the divided ſkin. This part contained the Butterfly's two fore-pair of legs, and its proboſcis.
b b The ſkin of the back, and abdomen, divided into two parts, that ſerved to encloſe the thorax, head, and four wings.
c The ſkin tore off near the origin of the abdomen, whoſe rings it heretofore contained.
d Some of the internal membranaceous caſes, or integuments of the horns, legs, and proboſcis. Theſe membranes are always broken on the Chryſalis's firſt appearing in the Butterfly form.
e e Some pulmonary tubes, diveſted of their integuments, and appearing in the ſkin itſelf.

FIG. XI.

The Butterfly, lately ſtript of its ſkins.

a Part of the body, which the wings do not as yet cover.
b b The ſmall ſpots and colour of the wings.
c c c c Four legs of the inſect.
d d The antennæ, or horns, growing over the the eyes, which are ſurrounded with hair. Between the horns are two ſhaggy forks, which hide the proboſcis.
e The two ſhanks of the proboſcis, hid between the ſaid forks.

FIG. XII.

A Butterfly, which in little more than a quarter of an hour after its firſt appearing as ſuch, has acquired its full growth and perfection, ſo as already to know what it ought to ſeek after, and what avoid; what may be uſeful to it, and what prejudicial. In this reſpect then, the Butterfly infinitely ſurpaſſes all other creatures, even man himſelf; and with a moſt audible voice, as it were, publiſhes to all mankind, the praiſes of their common Creator.

TAB. XXXVI.

FIG. I.

The ſtomach, and contiguous parts, with the vaſa incognita, or unknown veſſels, heretofore deſcribed; all which parts are now altered in a moſt ſurpriſing manner.

a a Folds and turnings of the vaſa incognita, exhibited already, Tab. XXXIV. Fig. V.
b Their origin, conſiſting of a ſlender tube.
c c Their diviſions and dilatations.
d The end of them, near the origin of the ſtomach.
e e The two curled-up or coiled ſhanks of the proboſcis.
f The origin of the gullet, near the root of the proboſcis.
g The channel of the pulmonary veſicle or bladder, ariſing from the gullet.
h The pulmonary bladder, or veſicle itſelf.
i i The ſtomach, conſiſting of many beautiful curled prominences.
k The hinder part of the ſtomach, like a wrinkled inteſtine.
l l l l Six vaſa varicoſa, or ſwollen guts, ſpringing by two origins from the little inteſtine below the pylorus.
m m The ſtraight guts, with their twiſts, and globular contents appearing through them.
n The inteſtine conſiderably dilated, ſo as to form the cloaca.
o Another dilatation of the inteſtine.
p The ſtraight gut. *q* The anus.
r r The two muſcles of the anus, furniſhed each with a tendon of a ſubſtance between bone and horn.

FIG. II.

The genitals of the Male.

a The penis, conſiſting partly of a horny bone, and partly of a nervous texture.
b b Two horny bones, ſituated one at each ſide of the penis.
c The articulation of theſe bones, with a border of the ſame ſubſtance, that goes round the penis in the form of a belt.
d d Another horny bone, belonging to the penis, divided in the middle.
e A back view of the diviſion of the ſaid part.
f The nervous root of the penis.
g g The body or root of the penis, beautifully curled or coiled.
h A granulated matter, like ſilver ſand, that flowed from a puncture made in the penis.
i The opening of the root of the penis.
k The diviſion of the nervous part of the penis.
l l l l Two beautifully curled ſeminal veſſels, iſſuing from the diviſion of the penis.
m m Two other ſtraighter veſſels, ſpringing from the ſame diviſion.
n A globular dilatation of the ſaid veſſels.

FIG. III.

The ovary, and its parts.

a a a a a The oviduct, divided at each ſide into three ducts, which afterwards terminate in very ſharp points.
b b The common ducts of thoſe already mentioned, ending in a ſingle trunk.
c c c c c Five veſſels, containing a glutinous ſubſtance,

ſubſtance, with which the Butterfly faſtens its eggs.

d The ovary, contracted into a narrower tube.

e An oblong bag, in the ſame place.

f Part of the ſaid bag, full of a yellowiſh matter.

g The lower part of it, full of a limpid humour.

h A little tranſparent part, like a ſheath or caſe, that contained a little horny bone.

i The aperture of the ſaid little horny bone.

FIG. IV.

The fat.

a a Some pulmonary fiſtules, ſerving to bind up the fat.

b b b The figure of the fat itſelf, very different from what it had in the Worm.

TAB. XXXVII.

The Butterfly encloſed in the Caterpillar.

No. I. The Butterfly, under the Caterpillar form, covered with its firſt ſkin, in which it is called an egg, and lies in the ſame manner that the Butterfly lies within the ſkin of the Chryſalis.

II. The ſaid firſt ſkin, or membrane, after it has been caſt off.

III. The Butterfly-Caterpillar, or the Butterfly in the form of a Caterpillar.

IV. The ſaid Caterpillar drawing near its change, and containing, within its ſkin, the Butterfly, expreſſed by the I. II. III. and IV. Figures.

a Its protuberant limbs and wings, which are not diſcernible about the ſecond annular ſection of the body.

b The ſame limbs, ſprouting out under the third ring.

c The hinder part of the body, growing ſmaller by degrees.

d d The beam to which this Caterpillar had faſtened its ſlight web.

e That part of the web, in which it had fixed the nails of its hinder feet.

f f A ligament compoſed of threads, with which the Caterpillar had girt itſelf about the middle of its body.

V. The Butterfly-Caterpillar, after it had ſhed its ſkin, in the Chryſalis form. This number ſhews all the limbs of the Butterfly already exhibited by the fourth, but more obſcurely, and diſpoſed in a different manner.

VI. The Butterfly itſelf, or Caterpillar-Butterfly, with its wings extended, and arrived at its full growth.

FIG. I.

The egg of a Caterpillar, which is a Butterfly, repreſented bigger than nature.

FIG. II. III. and IV.

The Butterfly, extracted from under the ſkin of the Caterpillar, exhibited by No. IV.

a a Its antennæ, or horns. *b* Its proboſcis.

c c Its four wings, placed between its ſix legs.

d d Annular ſections of its belly.

FIG. V.

All the ſaid parts of the Butterfly, as concealed in the Chryſalis.

a a a a The antennæ. *b* The broboſcis.

c c Four legs lying on the upper wings.

d d The upper wings, and part of the lower wings.

e The head and eyes.

f The belly and tail, with their ſections.

FIG. VI.

The parts, juſt now exhibited, diveſted of all their coats, repreſented more diſtinctly, and in their natural ſituation, ſo as to give an opportunity of even diſtinguiſhing the Butterfly's colours.

FIG. VII.

Exhibiting a black ſpot, appearing through the external ſkin of the Chryſalis, in one of the Butterfly's tranſparent wings. It may be certainly known, by the appearance of this ſpot, whether the Chryſalis is ſhortly to caſts its ſkin.

FIG. VIII.

The caſt ſkin of the Butterfly-Chryſalis, which almoſt always divides regularly into four parts.

FIG. IX.

Shewing the manner in which the Butterfly, with its wings as yet very ſhort and little, creeps out of its laſt ſkin, under which it was called a Chryſalis,

FIG. X.

The manner in which the wings of the Butterfly, exhibited by the IXth Figure, expand by degrees, and acquire their full growth.

FIG. XI.

All the limbs of this Butterfly, with its wings, in a growing ſtate.

a a The two antennæ, or horns.

b The curled proboſcis. *c c* The upper wings.

d d The lower wings. *e e* The ſix feet.

f The belly, its hairs, rings, and little feathers.

TAB. XXXVIII.

The mutations of the common Bog-houſe Fly.

No. I. The egg of the boghouſe Fly, of its natural ſize. The figure underneath repreſents it bigger than nature.

II. The double coat or ſkin of the ſaid egg, left by the Bog-houſe Worm, which at laſt changes to the Bog-houſe Fly.

III. The ſaid Worm newly hatched, a little bigger than nature.

IV. The ſaid Worm full-grown.

V. The ſaid Worm grown immovable, by degrees, under its ſkin, and changed to what I call a Vermiform-Nymph.

VI. The Bog-houſe Fly itſelf, proceeding from the Bog-houſe Worm, after the latter has changed into a Vermiform-Nymph, and and caſt off two ſkins.

FIG. I.

The egg of the Bog-houſe Fly, as it appears through the microſcope. It is oblong, full of angles, beautifully coloured, and teſſellated like the Dutch cakes, called Woffels.

FIG. II.

The double coat of the egg, broken by the Worm it contains. The external coat is of a ſubſtance like plaiſter; the internal coat, which is thinner, reſembles a membrane.

FIG. III.

The Bog-houſe Worm, as it appears through the microſcope, divided into annular ſections, and its body beautifully ſurrounded, as it were, with little tufts of feathers.

FIG. IV.

The ſame Worm changed into a Nymph, of a ſize bigger than nature, in order to ſhew that the little difference, as to external form, between this Nymph and the preceding Worm, (Fig. III.) conſiſts of no more than this, that in the Nymph ſtate the inſect's ſnout is drawn in within the head, and all the annular inciſions of the body are become ſhorter than they were in the Worm ſtate. Add that the inſect, in the Nymph ſtate, is deſtitute of motion, whereas in the Worm ſtate, it was very active and lively.

FIG. V.

The true or real Nymph, concealed within the Vermiform-Nymph, (No. V. and Fig. IV.) and thence extracted through inciſions made in the ſkin. This figure is a little bigger than nature.

FIG. VI. and VII.

The ſame Nymph (Fig. V.) viewed with a very great magnifier, the better to diſtinguiſh one from another; it's limbs, which are chiefly exhibited by the ſeventh Figure, and denoted by letters, as follows.

a a Are the reticulated eyes, between which, at the ſame time, may be ſeen the proboſcis, placed towards the thorax.

b The two antennæ, or horns.

c c The ſix legs, folded up on each ſide, againſt the thorax.

d d The folded wings.

e The abdominal rings, with the tubercles growing on the edge of the abdomen.

FIG. VIII.

The Bog-houſe Fly, (No. VI.) bigger than nature, with its external parts.

a a Two reticulated eyes, of a purpliſh colour, and parted by two ſilver belts or borders.

b Two antennæ on the forehead.

c c A pair of wings of a membranaceous ſubſtance.

d d d d Six hairy legs, the extremities of every one armed with nails.

e The abdomen, its rings, colour, and hairs.

FIG. IX.

A Another kind of Bog-houſe Worm, belonging to the ſecond mode of the third order or claſs. This worm is very remarkable on account of its legs and horns.

B The Vermiform Nymph of the Worm, from which it differs externally more than the Nymph heretofore exhibited, No. V. and Fig. IV.

C The Fly produced by the Nymph, elegantly covered, by ſome prepoſterouſly ranked amongſt Bees.

FIG. X.

D A white Worm, that grew within the Caterpillar of Tab. XXXVII. No. III. and aftewards, when near its time of mutation, opened itſelf a paſſage through the Chryſalis of the ſaid Caterpillar, repreſented by No. V. of the ſame Table.

E The ſame white Worm changed after its iſſuing from the ſaid Chryſalis, into a Vermiform-Nymph, that being opened is found to contain a real Nymph.

F The Fly at length produced by the ſaid Vermiform Nymph, after it has caſt its ſkins.

TAB. XXXXI.

The Hiſtory of the Aſilus, or Gadfly.

FIG. I.

The Worm from which the Gadfly iſſues, hanging over the ſurface of the water.

a Twelve annular diviſions of the Worm, by which it is divided, as it were, into head, thorax, and belly.

b Hairs growing round the tail, in a circular form, by means of which this part floats on the ſurface of the water, while the reſt of the body remains under water, with its downwards.

c The head, whoſe mouth is divided into three parts. The two lateral parts, which are, properly ſpeaking, the inſect's feet, vibrate, while it remains alive, like the tongues of ſerpents.

FIG. II.

Another kind of theſe Worms, in its deſcent to the bottom.

a The hairs of the tail, diſpoſed in an oval form, and containing a bubble of air within their cavity.

b Two bubbles of air, diſcharged by the Worm at its breathing-holes, tending to the ſurface of the water.

FIG. III.

A microſcopical view of the firſt Worm.

1 2 3, &c. Twelve rings, by which it is divided into head, thorax, belly, and tail. This figure likewiſe ſhews in what manner the ſkin is beautifully covered with minute grains and ſpots. On one ſide too there appear nine breathing-holes.

a The tail, reſembling a ſtar, compoſed of beautiful hairs.

b b Delicate hairs, which in this figure appear only about the ſides of the body, as I have omitted repreſenting them on its upper part, or on the inſect's back.

c c. Two larger hairs, growing on each ſide of the body.

d The head. *e e* The eyes.

f The crooked ſnout.

g g The legs, ſituated near the ſnout.

h h Two blackiſh horny bones, which are, as it were, the thumbs of the feet.

i i The horns, or artennæ.

FIG. IV.

The grains of the ſkin, viewed with a great magnifier, ſo as to ſhew their conſtruction.

a The ſkin appearing between the grains.

b The prominent part of the ſaid grains, exexactly in the middle.

c The irregular rings of the ſaid grains.

d Sharp prickles growing on the edges of the grains, to whoſe firmneſs they contribute.

FIG. V.

A leg, magnified.

a Three muſcles, furniſhed with a tendon, of a ſubſtance between bone and horn, and placed on one ſide of the firſt joint of the leg.

b The ſaid joint, which is black, and likewiſe of a ſubſtance between bone and horn.

c Two ſmaller muſcles, with their tendons.

d Another joint, of a ſubſtance between bone and horn.

e The extreme joint of the leg, with its briſtly hairs.

f The thumb of the foot.

FIG. VI.

The ſnout inverted, and bigger than nature.

a The ſnout, and all its parts.

b The ſharp and crooked extremity of the ſnout.

c The internal opening of the mouth, through which the inſect's food paſſes to the gullet.

dd The membranaceous diviſions of the mouth, by which the palate can be bent, and made to give way.

e Part of the mouth, entirely conſiſting of a black horny bone.

FIG. VII.

The ſalival veſſels, or at leaſt two parts analogous to ſuch veſſels.

a Two ſalival veſſels curled, and ending in blind extremities.

b A ſingle channel, in which they terminate.

c c Two particles, as it were, reſembling muſcles.

d The upper part of the mouth, from which the eyes, and two parts of the head, ſupporting the eyes, have been ſeperated.

TAB. XL.

FIG. I.

The Worms pulmonary tubes.

a a Two very conſiderable branches of the pulmonary tubes.

b Pulmonary tubes in that part where the optic nerves, and the membranes of the growing eyes, are ſituated.

c c c Some pulmonary tubes, which run into each other from each ſide of the body.

d d d d d d A mutual communication of the pulmonary tubes, at each ſide of the body, under the ſkin.

e e e e The circumference of the ſkin, denoted by dots.

f The tail, in which the two main trunks of the pulmonary tubes are opened by two channels.

FIG. II.

Curls or folds of the pulmonary tubes.

a a Two portions of the pulmonary tubes drawn aſunder.

b Their curly foldings, which repreſent a ſilver wire wound up in a ſpiral form, and then extended.

FIG. III.

The fat.

a Irregular figures of the fat.

b Its round particles. *c* Its oblong particles.

d Its broad, jagged, or indented particles.

e Its angular particles.

f Particles in form of a pear.

g Pulmonary tubes diſtributed through the fat.

FIG. IV.

The heart.

a a The lower part of the heart, in ſome places a little dilated.

b b Part of the heart, repreſented bigger in the abdomen and thorax.

c Part of the heart, ſeated about the head, and again contracted.

FIG. V.

The brain.

a a The brain.

b A cleft or opening in the ſpinal marrow, to give a paſſage to the gullet.

c c Part of the eyes of a future Nymph, and Fly growing by degrees.

dd Eleven prominent nodules of the ſpinal marrow

e e Nerves ſpringing from the origin of the ſpinal marrow.

f Nerves iſſuing from the origen of the ſpinal marrow towards the ſides of the body.

g g Nerves ſent from the eleven nodules of the ſpinal marrow to the viſcera, and other parts.

TAB. XLI.

FIG. I.

The Worm changed within its ſkin into a Nymph.

a a a The external ſkin hardened, and contracted into three bendings.

b c d e The four laſt rings of the abdomen, which, on account of the contraction of the body, contain nothing but air.

f A hollow or empty ſpace in the external ſkin, between the head of the Worm and the encloſed Nymph. This hollow appears more obſcurely than that under the four laſt rings of the abdomen.

g The encloſed Nymph, known by a black ſpot appearing externally on the ſkin's ſurface.

FIG. II.

The ſkin opened, ſo as to give a ſight of the encloſed Nymph.

a The Nymph ſtill wrapped up in its thin and delicate ſkin.

b b Its unfolded pulmonary tubes, of which there are four repreſented in this figure.

c The ſkull caſt off, with the other parts of the horny head, and the ſnout.

FIG. III.

Parts of the future Nymph, diſcerned in the Worm when ſtripped of its ſkin.

a a The antennæ, or horns.

b The head and proboſcis.

c c The firſt pair of legs. *d d* A pair of wings.

e e Another pair of legs. *f f* A third pair.

g The abdomen, and its rings. *h* The tail.

i i Pulmonary tubes, which have in part ſhed their coats.

k Inteſtines likewiſe, which have partly caſt their coats.

l The anus cut off, but ſtill hanging to the inteſtines.

FIG. IV.

The Nymph, or parts juſt now taken notice of in the Worm, diſpoſed in a beautiful manner, and much bigger than nature.

a a The antennæ, or horns.

b b The eyes, in which the hexagonal diviſions do not as yet appear.

c The proboſcis under the head.

d d. The firſt pair of legs.

e e The ſecond pair.

f f Two wings, elegantly folded.

g Annular diviſions of the thorax.

h The third pair of legs.

i i Some black ſpots on the inſect's body,

k k k k Four openings of the lungs.

FIG.

The fat of the Nymph.

a Changes or alterations in the configurations of its parts.

b b Some ramifications of the aſpera arteria diſtributed through the fat.

FIG. VI.

The ſtomach and inteſtines of the Nymph, to which are added the head and tail of the Worm.

a The origin of the gullet.

b The horny bone of the head; the ſnout, and the legs drawn in towards the body.

c The gullet running towards the ſtomach, through a ſlit or cleft in the ſpinal marrow, under the brain. Theſe particulars have been repreſented in this manner, to make them the more intelligible.

d The ſtomach, with its wrinkled foldings, and pulmonary tubes.

e Oblong furrows in the ſtomach.

f An open tube, appearing through the tranſparent coats of the ſtomach, within which it is faſtened.

g The ſmall gut, forming ſix foldings.

h A little gut, within the former, where it likewiſe makes a variety of folds.

i i The curled windings of the ſaid little inteſtine.

k The dilatation of the ſmall guts, and places where it produces four blind guts, that ſpring from a common trunk.

l Places where the thick guts unite with the ſmall guts.

m m Some globular dilatations in one of the blind guts, and the wonderful diviſions of its contents.

n n Surpriſing windings and folds of the blind guts.

o The place where two of the upper blind guts unite into one.

p p Windings of another, or the other upper blind gut.

q q Windings of the third.

r The blind extremity of this laſt.

s s Windings of the fourth blind gut.

t The blind annular extremity of this laſt.

u Dilatations of the colon, in form of nodules.

x The larger dilatation of the colon.

y The two ſmalleſt dilatations of the colon.

z The anus, below the ſtraight gut.

FIG. VII.

The ſpinal marrow in the Nymph and Fly.

1 2 3, *&c.* Eleven nodules of the ſpinal marrow, now extended at full length, and drawn out one from another.

a The brain; and above it a rough draught of the tunicæ corneæ of the eyes, and their hexagonal diviſions.

b The firſt nodule of the ſpinal marrow, retaining its primitive ſituation.

c The four following nodules, which now form a conſiderable knot or ſwelling, at the ſame time that the ſixth, ſeventh, and eighth are are ſeparated one from another, and the ſpinal marrow between them is drawn out.

d The three laſt nodules, continuing in their former ſituation.

TAB. XLII.

FIG. I.

The external ſkin ſhed by the Gadſly, with the manner of its ſhedding it.

1 2 3, *&c.* Theſe numbers, placed in oppoſite ranks, ſhew the twelve rings of the Fly, or Worm's ſkin.

a The third and fourth rings: it is in this place that motion is firſt perceived in the Worm's ſkin, when the Fly is about to break forth. And for this reaſon theſe rings burſt open in a longitudinal direction.

b The third fore ring, or, counting from the tail, the tenth, which burſts open in a contrary direction into two parts, one of which continues faſtened to the ſecond, and the other to the fourth ring.

c The fourth ring opens almoſt in the ſame manner, only that it cleaves more in the middle.

FIG. II.

A general view of the external limbs and parts of the Gadſly.

a Its two antennæ, or horns.

b b b b The ſix feet, and their joints.

c c The wings. *d* The abdomen.

FIG. III.

A diſſection of the Gadſly. The external ſkin and internal coat ſhed by the Gadſly.

1 2 3, *&c.* Rings of the external ſkin.

a a Pulmonary tubes, rolled off, in the ſecond, third, and fourth rings.

b b The curled extremities of the tubes.

c An inteſtine, ſhed likewiſe by this inſect, containing ſome tranſparent particles like ſand, which ferment with acids.

d The caſt legs, ſnout, and eyes.

e The caſt ſkull.

f Coats or ſkins, ſhed by the gullet and the ſtomach.

g g The caſt internal coat, which immediately encloſed all the limbs of the Nymph.

h The place where the coat contained the Fly's tail.

i i Pulmonary tubes caſt off within the delicate little ſkin.

k The largeſt of theſe tubes, with its ramifications.

FIG. IV.

A rough draft of the manner in which the Inteſtine ſheds its ſkin.

a The internal coat of the inteſtine *b*. This inteſtine comes away full of grains of ſand.

b The inteſtine itſelf, remaining in the body.

c The anus, with the internal coat of the inteſtine *b*, ſhed by the inſect, ſtill faſtened to it.

FIG. V.

The proboſcis magnified.

a The two fore parts of the proboſcis, of an oval form.

b Hairs growing from the ſkin of the proboſcis.

c c Two articulated briſtles, or appendages of the proboſcis, ſpringing from within its root.

d A triangular horny bone, ſurrounding the root of the proboſcis.

e Another little bone like the laſt in ſubſtance, but of a different form.

FIG. VI.

Some of the pulmonary veſicles.

a Its membranaceous part, which was full of air.
b The pulmonary tube, through which the air paſſes to the veſicle.
c Two lateral pulmonary tubes.

FIG. VII.

The genital parts of the male.

a The penis and its two appendages.
b b Two twiſted horny bones belonging to the penis; and articulated with the ſheath, through which the penis erects itſelf.
c The flexible part of the penis.
d d Two little black horny bones, forming a border round the extreme ring of the abdomen; and articulated with the former bones.
e e Places where the articulations appear.
f The nervous body of the penis.
g A dilatation of the root of the penis, with which the vaſa deferentia, and ſeminal veſſels empty themſelves.
h h The teſticles. *i i* The ſeminal veſſels.
k k Short tubulated ſeminal veſſels, laid bare in one of the teſticles.
l Veſſels for the conveyance of the ſeed.
m m Windings of the ſeminal veſicles, the extreme ends of which are dilated.

FIG. VIII.

The ovary of the female.

a a The ovary conſiſting of two parts.
b The laſt rings of the abdomen.
c c c Some protuberances of a ſubſtance between bone and horn, appearing like ſpots on the laſt abdominal ring.
d Hairs growing in the ſame place.
e e e Eggs belonging to one ſide of the ovary, as yet in their natural ſituation.
f The ſame eggs a little more magnified, and removed out of their natural ſituation. The remaining part of this ovary is marked by dots.
g Pulmonary tubes interwoven with the ovary.
h Some branches of the ſaid tubes diſperſed both within and without the coats of the eggs.
i i The greateſt extreme branches of the ſaid tubes.
k Two ducts of the ovary, by which the eggs are let out of the body.
l Three beautiful unknown particles, each ſupported by its ſtalk,
m The point of the inflexion of theſe tubulated particles.
n Their tubes and windings.
o That end of the tubes which lies neareſt to the duct of the ovary.

TAB. XLIII.

The Hiſtory of the Acarus, or Mite.

FIG. I.

The Acarus or Mite, of its natural ſize.

FIG. II.

A microſcopical view of the Acarus.

1 2 3 4 5 6 7 8 9 10 11 12 The twelve rings of the body.
a The head, in which are ſeen two nails belonging to the inſect's legs, with which, when about to ſpring or leap up, it compreſſes its anus.
b The larynges or tops of the aſpera arteria, projecting beyond the ſkin.
c c The place where there iſſue from the main tranſparent trunks of the aſpera arteria, two branches, which unite by a mutual anaſtomoſis, or inoſculation with the branches of the fourth ring.
d d d d d d d The inoſculation of the pulmonary tubes, which appear through the remaining rings of the body.
e A particle of the fat appearing through the ſkin.
f f Some blind guts, appearing in the ſame manner.
g A conſiderable branch of the aſpera arteria, which appears through the ſkin under the tenth ring, between the two principal branches of the trachea.
h A beautiful particle of fat, appearing under the eleventh ring, and near which may be diſcoverd the two extremities of the branches of the trachea.

FIG. III.

The manner in which the Worm bends itſelf into a circle, in order to prepare for leaping.

FIG. IV.

The manner in which the circular form changes to an oblong one; juſt as the Acarus is about to leap or ſpring.

FIG. V.

The feet, parts of the mouth, ſtomach, inteſtines, and ſome other viſcera of the Acarus, as viewed with the microſcope.

a a The feet or teeth, and nails.
b b Origin of the horny bony parts of the mouth, and palate.
c c Four appendages of the ſaid parts.
d Horny bones, which ſerve to keep all the parts in their proper ſituation.
e The dilatation of the gullet, which I call the ingluvies.
f f Four blind appendages under the ingluvies.

g g The ſtomach, of a conſiderable length.
h h h Ramifications of the aſpera arteria, viſible in the ſtomach.
i Contents of the aſpera arteria, appearing through its tranſparent coats.
k k The origin of the blind guts, of which this inſect has four.
l l Two of the ſaid guts, containing a yellowiſh green ſubſtance.
m The two others, whoſe contents reſembled a coagulated ſubſtance.
n Pulmonary tubes, belonging to a blind gut, of the ſame kind.
o The pylorus. *p p* The colon.
q The ſtraight gut. *r* The anus.
s s Two particles of fat, and their diviſions, with which one of the blind guts is interwoven.
t t Two glandulous ſwellings, and channels of the ſalival duct, which runs along the gullet to the jaws in form of a ſlender tube.
v v Two other ſwellings, with their channels and pulmonary tubes.
x x Some particles of fat, and their diviſions.
y y Two other particles of the ſame kind, which ſhew themſelves in the ſame place like appendages in the form of a chain.

FIG. VI.

Diviſions of the particles of fat, magnified to a greater degree.

a a a Seven diviſions of the particles of fat, in which it is laid up in the form of oily, ſpherical particles.
b The manner in which the pulmonary fiſtules paſs through the cells that contain the fat.

FIG. VII.

The brain, ſpinal marrow, and nerves, bigger than nature.

a a The right and left lobes of the brain.
b b The nerves, iſſuing from the upper part of the brain.
c The nodules, formed by the ſaid nerves.
d d Two fine nerves, iſſuing from the ſaid nodules, and running to the muſcles of the head and legs.
e e Two pair of muſcles ſent by the ſpinal marrow to the muſcles of the thorax.
f f Two ſtrong nerves, with their dilatations, adminiſtering to the muſcles that ſerve to move the wings.
g g A great many fine nerves diſtributed amongſt the muſcles, and viſcera of the abdomen.
h h h Ramifications of the ſaid nerves.

FIG. VIII.

A ſide view of the ſpinal marrow and brain.

a The brain.
b The ſinus of the ſpinal marrow.
c A cleft in the ſpinal marrow for the paſſage of the gullet.

FIG. IX.

Some of the muſcles.

a a a The oblique deſcending muſcles with two bellies, of each of which, one of the tendons is inſerted into the muſcle itſelf.
b b The broad tranſverſe muſcles.
c c The The oblique aſcending muſcles.

FIG. X.

The Acarus, or Mite, contracted, in which condition I call it a Vermiform-Nymph.

FIG. XI.

The ſame, bigger than nature.

a The head and mouth.
b The tail and its tubercles.

FIG. XII.

The concealed Nymph, extracted from the contracted or ſhrivelled ſkin of the Acarus.

FIG. XIII.

The ſame Nymph, bigger than nature.

a The two horns of the future fly.
b b The eyes. *c* The proboſcis.
d d The firſt pair of legs. *e e* The ſecond,
f f The folded wings.
g g The third pair of wings.
h The rings of the body.

FIG. XIV.

Two flies iſſuing from the Acari, or Mites, of their natural ſize.

FIG. XV.

A microſcopical view of the male fly, produced by the Acarus or Mite.

a The antennæ or horns.
b b The firſt of legs, their joints, hair, and nails.
c c The ſecond pair. *d d* The third.
e e The wings and little hammers placed under them.
f The rings of the belly.

FIG. XVI.

The ſkins caſt by the Acarus, bigger than nature.

a The upper part of the torn ſkin, where the fly creeps out.
b The lower part.

FIG.

FIG. XVII.

The genital parts of the male.

a The horny part of the penis, curled in a ſurpriſing manner.
b The membranaceous part of the penis.
c The fore end of the penis, which is here repreſented as it receives the vulva of the female, inſtead of being received by it.
d The nervous root of the penis.
e The place where the root of the penis is dilated.
f f The teſticles of a yellowiſh red.
g g The vaſa differentia.
h h Spherical appendages of the veſſels.
i i The ſeed bags. *k k* The proſtata.

FIG. XVIII.

The external parts of the uterus and vulva.

a a The two laſt rings of the body.
b b The firſt joint of the extremity of the uterus, covered with hair, and furniſhed with two little black horny bones.
c c The ſecond joint encloſed in the firſt. The extremity of this ſecond joint is likewiſe of a ſubſtance between bone and horn.
d The third and laſt joint, formed of the ſaid ſubſtance, and covered with hair. This joint is received by the penis.

FIG. XIX.

One of the ſixty-four oviducts.

a A perfect egg lying in the oviduct, of a white colour.
b Three imperfect eggs of a watery colour.

TAB. XLIV.

Obſervations on the Vermicles, or little Worms, found in the tubercles of the leaves of Willows.

FIG. I. II. and III.

Tubercles of Willow leaves, the eggs, and Worms repreſented by ſix ſeveral figures.

FIG. I.

a The external ſide of the leaf.
b b The internal ſide.
c c The warts or tubercles, of an oval round.
d Others of an oblong form.
e Others full of wrinkles.
f Very ſmall warts, which look rotten, as it were.
g Warts, or tubercles, growing on the greater or main nerves.
h Another on the extremity of the leaf
i Another growing on the nerve itſelf.
k Others, which riſe on each ſide to an equal height, above the coats of the leaf.
l Some on the ſtalk of the leaf.
m Seven rudiments of tubercles exhibited on each ſide of the leaf.

FIG. II.

n The egg, that is found in the rudiments of the tubercles.

FIG. I.

o A tubercle with a cleft in it, through which the egg may be ſeen placed in the middle.

FIG. II.

p An egg magnified, ſo as to ſhew the head and two eyes of the encloſed Worm, that appear through its tranſparent ſkin.

FIG. I.

q The Bindweed Caterpillar, full grown.
r The ſmall hole bored by it through the tubercle or wart.

FIG. III.

A microſcopical view of the ſame Caterpillar.

s The eyes. *t t* The ſix fore feet.
u Six of the twelve middle feet.
x The two hinder feet, next the tail.

FIG. I.

y The manner in which the Caterpillar thruſts its anus out of the hole, made by it in the tubercle, and thereby diſcharges its excrements.
z z Two ruſty coloured ſpots of the Willow-leaf; one of them with a hole in it, within which may be ſeen the nerves of the leaf, and the excrements and head of another Worm, that lives in it. Fig. VIII. exhibits this Worm of natural ſize.

FIG. IV. V. and VI.

The Fly's web, and the Fly itſelf; likewiſe thoſe parts of the Fly, with which it bores itſelf a paſſage through the tubercle or wart; in five figures.

FIG. IV.

a The oval web of the Fly.
b The Fly itſelf.

FIG. V.

The Fly ſeen through the microſcope.

c The antennæ or horns.
d d The black ſpots on the wings.
e e Six legs, their joints and two nails to each leg.

FIG. VI.

The parts with which the female bores the leaf.

f f The laſt rings of the abdomen.
g An inſtrument like a ſaw.
h h Two pointed horny bones.

FIG.

FIG. IV.

i A little lid or cover, which the Flies at their firſt appearance thruſt out of their web, as out of a little barrel.

FIG. VII.

A microſcopical view of a very ſmall inſect, which reſts on the external ſurface of the Willow tubercles or warts.

FIG. VIII.

The little Worm found between the coats of Willow leaves, of its natural ſize. See Fig. I. let. *z z.*

FIG. IX.

A microſcopical view of the ſame Worm.

a The head and two teeth.
b b Its broad thorax, and tranſparent pulmonary fibres.
c c The other rings of the body, which is covered with hair, and ends in a pretty ſharp point.

FIG. X.

The Nymph, in which the Worm is afterward exhibited changed, a little magnified.

FIG. XI.

The ſame Nymph more magnified.

a Two crooked briſtles on the head.
b b Its horns and antennæ.
c c The ſecond and third pair of legs: The ſecond is armed with two briſtles.
d d Two ſheaths to cover the wings.
e e The third pair of legs, and their briſtles.
f The wings of the body, and the prickles and ſtings of the tail.

FIG. XII.

The Beetle produced by the ſaid Nymph.

FIG. XIII.

The ſame Beetle magnified.

a Its reticulated eyes.
b Its ſnout or beak, of a ſubſtance between bone and horn.
c c Its antennæ or horns.
d d d Its ſix Feet, upon the leaſt pair of which this inſect makes it ſprings or leaps.
e e The ſheaths of the wings.

FIG. XIV.

Rudiments of Willow leaves juſt beginning to ſhoot or bud.

a Four of there young leaves, with their ſtalks and rough ſurfaces.
b Red Worms, generally found within the leaves.

FIG. XV.

A microſcopical view of a Fly produced by one of the Worms.

FIG. XVI.

A tubercle or wart growing in the Willow in form of a roſe.

a The tubercle and its ſtalk.
b A pyramidal cluſter of leaves, within which the Worm lies.

FIG. XVII.

Repreſenting in five figures all the changes of the Worm, and its tubercle.

c The manner in which the leaves of the tubercle may be ſeparated one by one.
d Part of the Worm's body, that lies in the middle of the cluſter.
e A delicate membrane or web, more immediately encloſing the Worm.
f The Worm itſelf. *g* Its Nymph.
h The Fly to which the Nymph changes.

FIG. XVIII.

An Alder leaf with various Worms between its two coats.

a The coat of an Alder leaf ſwelled into a tubercle, on account of the Worm that had made its bed under it.
b b The upper coat or ſkin removed, in order to ſhew on each ſide, how the other coat is contracted underneath into a ſmall fold.
c The web encloſing a Chryſalis, diſſected; and near it the excrements of the Worm formerly contained between the two coats of the leaf.
d Another Worm with ſix feet, found likewiſe between the coats of the Alder.
e A third ſpecies of Worms found in the ſame place, with the ſkin caſt by it, and its excrements.
f Two oblong webs made in their cells by the ſaid Worms.
g Part of the leaf, where the ſame Worm is found, when as yet very ſmall.
h The ſame part, where the Worm has made itſelf more room.
i Another cell or neſt like the former, but a great deal more ſpacious.

FIG. XIX.

A microſcopical view of a Chryſalis found in its web within the coats of an Alder leaf.

a The ſharp pointed head of this Chryſalis.
b The hinder part of its body, formed like a pear.

c c Fine hairs growing on its body.
d d Its eyes. *e* Its proboſcis.
f f Its firſt and ſecond pair of legs.
g g g g Its anntenæ or horns. *h h* Its wings.
i The laſt pair of legs lying between the antennæ.
k k The rings of the body.

FIG. XX.

The Butterfly produced from the forgoing Chryſalis, drawn after nature.

FIG. XXI.

A micrcoſopical View of the ſame Butterfly.

a a The antennæ. *b* The proboſcis.
c c The upper pair of wings, beautifully coloured.
d d The lower pair of wings, for the moſt part covered with feathers.
e e Three white hairs, like thorns, growing on the hinder legs.

TAB. XLV.

A ſhort explanation of the figures ſerving to illuſtrate ſome of the foregoing hiſtories.

FIG. I.

The manner in which the Fly lays its eggs, within the leaves of the common Thiſtle; which eggs afterwards produce Worms.

FIG. II. III. IV. and V.

The Tubercles or Warts of the ſtinging Nettle, with the Worms and Nymphs found in them, and the Flies produced by the ſaid Nymphs, in four Figures.

FIG. II.

a Some excreſcencies growing on the ſtalk.
b Some tubercles or warts of the ſame kind, on the nerve of the leaf, and on the rudiments of the young leaves.
c Others growing irregularly on the leaf.

FIG. III.

d The Worm found in the tubercles of the Nettle, of its natural Size.
e A microſcopical View of the ſame, ſomewhat broader in the middle.
f A fine or ſlender ſnout projecting from its extremity.
g Fine hairs growing on its body.

FIG. IV.

h The Nymph magnified to a greater ſize, with very large eyes in its head. Here are likewiſe to be ſeen its horns, legs, wings and abdominal rings.
i Its little tail bent backwards.

FIG. V.

k The Male Fly of its natural ſize.

FIG. VI. VII. and VIII.

The downy excreſcencies growing upon Oak trees, with little hollow bags or tubes, and the Flies engendered and living in them.

FIG. VI.

a a a The circumference of the downy ball or globe, after its natural condition.
b The ſtalk ſupporting it.
c An Oak leaf growing out of the middle of the ball.

FIG. VII.

d Bags or tubes, within which the Worms turn into Flies, and in whoſe circumference the downy hairs of the ball are principally rooted.

FIG. VI.

e e Little holes, which the Flies gnaw in the downy ſubſtance in order to eſcape out of their cells.

FIG. VIII.

f The Fly itſelf of its natural ſize.

FIG. IX. X. and XI.

The ſpongy tubercle of the wild Roſe: The ſame laid open in the middle: Laſtly, the Flies bred in it.

FIG. IX.

a a Knobs and inequalities of the tubercles.
b The ſtalk ſupporting it.

FIG. X.

c A ſection thro' the middle of the ſaid tubercle, ſhewing the cells in which the Worms grow to be Flies.

FIG. XI.

d The firſt ſpecies of Fly that iſſued from the ſaid tubercles, with a pretty thick body.
e The other ſpecies of the biſeta, or two haired kind.

FIG. IX.

f Round holes knawed by the Flies in the ſpungy tubercle, in order to get out of their cells.

FIG. XII. XIII. XIV. XV. and XX.

The tubercles or warts growing on Oak leaves: One of them opened: The kidneybean-like ſubſtance found in them: A tubercle cut off from the leaf: A microſcopical view of the bean-like ſubſtance: The manner in which the tubercle dries up or withers.

FIG. XII.

a a Excreſcencies found on the fore end of the leaf, and likewiſe a little higher up, on the leaf's nerve or main rib.

b Two tubercles; one of them a double one, growing ſtill a little higher up on the nerve or main rib; the other almoſt on the edge of the leaf.

c c Some tubercles on the extremities of the leaf.

FIG. XIII.

Containing five drawings.

d The upper part of one of the tubercles cut off.

e Three diſtinct excreſcencies like kidney-beans, found in the hollow of the tubercle.

f Three excreſcencies like beans, taken out of the hollow cell or cavity.

FIG. XIV.

A tubercle or wart of the ſame kind cut open, and exhibiting two kidney-like beans lying in it, in the ſame manner that a preſerved almond lies within its candied covering, without any intermediate vacancy. This is a microſcopical view, ſhewing the objects a little larger than nature.

FIG. XV.

g The bean-like ſubſtance, with an uneven ſurface.

h That part of the bean, by which it principally adhered to its tubercle, and received its nouriſhment.

FIG. XX.

i i The manner in which the tubercle begins to leſſen, and wither up by degrees, ſo as to become fit for the impreſſion of the Fly's teeth, and thereby afford it an opportunity of eſcaping.

FIG. XII.

k A ſmall round hole, gnawed by the Worm in the withered part of the tubercle, and thro' which it iſſues into the open air.

l l Places where the tubercles dry up, and which may be ſeen without cutting it.

m The Worm cut out of its bean-like part, and repreſented of a ſize bigger than nature, on an Oak leaf.

FIG. XVI.

The ſame Worm ſtill more magnified, and of the form in which it appears, when about to enter the Nymph ſtate.

FIG. XVII.

The ſame Worm changed into a Nymph, and viewed with a greater magnifier in order to ſee its limbs more conveniently.

a a Its eyes, reſembling a net.

b b The antennæ lying between the legs and the wings.

c The abdominal wings.

FIG. XVIII.

The ſame Nymph, changed to a Fly, of its natural ſize.

FIG. XIX.

The ſame magnified.

a a The antennæ placed before the eyes.

b b The four wings.

c c The leaſt pair of its ſix legs, every one of which is armed with two nails.

d The ſharp extremity of the abdomen, with which the Fly bores holes in the Oak leaf for the reception of its eggs.

FIG. XXI.

Repreſenting, in two drawings, the excreſcence growing on the leaves of the black Poplar, with the Worms and their food contained therein.

a A wrinkled excreſcence in the external coat of the leaf.

b The principal rib of the leaf.

c The internal ſide of the leaf, where the wart or tubercle opens into a ſlit or opening.

d d Windings of the principal nerve or rib, in the external coat of the leaf.

FIG. XXII.

A microſcopical view of one of theſe very minute Worms, that is furniſhed with two horns, two eyes, and ſix feet; and is moreover divided into head, thorax, and abdomen.

e A woolly or downy ſubſtance, which theſe little inſects very beautifully wear on the hinder part of their bodies.

FIG. XXIII.

f The inſects glutinous food, contained within the woolly or downy ſubſtance, and reſembling a veſſel with a ſpout uſed to feed infants.

g The manner in which the downy ſubſtance curls up, when its moiſture is conſumed.

FIG.

FIG. XXIV.

h h Two pair of cups or membranaceous buds, in which the wings grow, and are encloſed as it were in little bags.

FIG. XXV.

A microſcopical view of the ſame Worm changed into a Fly with four wings.

FIG. XXVI.

The footleſs Worm, found on the leaves of the Cabbage, of its natural ſize.

FIG. XXVII.

The ſame Worm changed into a Nymph, repreſented lying on its belly, and of its natural ſize.

FIG. XXVIII.

A microſcopical view of the ſame Nymph, and in the ſame poſture, with its limbs as appearing through their tranſparent integuments.

a a The eyes.
b The thorax and ſome of the hairs growing on it.
c c c The abdominal rings.
d One of the rings
e The curled, or folded, caſt off ſkins, of a pulmonary tube.
f f Part of the Cabbage leaf, to which the Nymph glues itſelf by this membrane.

FIG. XXIX.

A microſcopical view of the ſame Nymph, diveſted of its caſt ſkins, and placed on its back.

a An eye, of one ſide. *b* The two horns.
c The proboſcis. *d d* The folded wings.
e The hinder pair of legs.
f f The extremities of the genitasl, which lie, as it were, out of the abdomen.

FIG. XXX.

The Fly of the ſaid Nymph, of its natural ſize.

FIG. XXXI.

The cell, or neſt of the Moth; the encloſed Worm of the Moth; the ſame extracted; likewiſe its Chryſalis and Butterfly; alſo the manner by which the ſkin of the Chryſalis remains faſtened to the fore end of the cell or neſt: Laſtly, the very fine threads or filaments, with which the neſt or cell is lined.

a The cell, ſpacious in the middle, but narrower at each end.
b The thread formed by the Worm, and by means of which, to avoid falling, it hangs and faſtens itſelf to the beams and walls of buildings.
c The manner in which the Worm of the Moth creeps out of its caſe or cell by the fore feet, and faſtens itſelf with a thread of its own ſpinning, in ſome convenient ſituation.
d The Worm itſelf of its natural ſize, with ſixteen feet.
e The ſame changed into a Chryſalis.
f The Chryſalis changed into a winged Butterfly or inſect, called a Moth.
g The caſt ſkins of the Chryſalis, projecting a little beyond the caſe.
h The internal ſurface of the caſe, very even and ſmooth.

FIG. XXXII.

A ſmall Worm found in muſk-bags, and its changes.

a The Worm. *b* Holes made by it in wood and paper.
c Its oval web. *d* Its Nymph.
e The Beetle produced by the ſaid Nymph.

FIG. XXXIII.

A Worm found upon leaves, in very black caſes.

a The manner in which the Worm carries its caſe about with it.
b The Fly produced by the ſaid Worm.

FIG. XXXIV.

Another ſpecies of a Worm, that carries its caſe or cell about with it.

c The cell of a triangular form at its upper end.
d A nocturnal Butterfly or Moth, into which the ſaid Worm changes.
e A Fly, into which another ſpecies of theſe Worms changes.
f A little Fly, into which the third part of the ſaid Worms was changed. I found ſix or ſeven of theſe very minute Worms.

FIG. XXXV.

A pyramidal cell, formed by a Caterpillar that inhabits it, and moves about with it. This cell or tube is compoſed of bits of wood, ſo as to reſemble a piece of cheque or moſaic work.

FIG. XXXVI.

A tube or cell formed of ſand by a Sea-Worm.

TAB. XLVI.

The ſlow growths or accretions of the Frog, and Garden Clove-July-Flower, in which they reſemble the inſects.

The figures on the left hand ſide exhibited.

No. I. The Frog's egg, or the Worm of the Frog, within its firſt coat, or integument,

reſembling a little globe or ſphere, encloſed by another greater globe.
a The encloſed globe forming, as it were, the yolk of this egg.
b b The encloſing globe, reſembling the white of the egg.
II. The Worm of the Frog diveſted in a manner, of its firſt coat.
c The coat removed to the hinder part of the Frog's Worm.
d The Frog's Worm rolled out from under the ſaid coat.
e e e Its food, like the white of an egg ſurrounding it.
III. The Tadpole or Worm of the Frog grown bigger, and floating in the middle of its food.
f f f The food ſwimming, or floating in the water, like an expanded cloud.
g The head, breaſt, and abdomen, made up as it were in one globe or ſphere.
h The tail.
IV The ſame Tadpole more grown, ſhewing its fore legs, which encreaſe by degrees as do likewiſe the hinder legs, but ſtill under the ſkin.
i i The fore legs growing out by degrees.
V. The Nymph of the Frog, or the Tadpole ſufficiently grown, and in a condition to become a Frog, as all the limbs of the Frog have acquired in it their due perfection, ſo that to appear in the form of a Frog, it need only caſt its external ſkin.
k k The fore legs, which by degrees have acquired their perfection under the ſkin.
l l The hinder legs, which are likewiſe perfect, and project beyond the ſkin.
VI. The Frog itſelf, arrived at length at the ſtate of a perfect animal, after paſſing through the various forms, of egg, Worm, and Nymph. It is not however, like inſects, immediately fit for generation, but muſt wait ſome years to attain that degree of perfection.
m m Two veſicles growing near the eyes of this Frog, which ſhew it to be a male one.

The figures on the right hand repreſented.

No. The garden Clove-July-Flower in its firſt coat, in which ſtate it is called ſeed.
A. A microſcopical view of the ſeed itſelf, in which may be ſeen the cicatrix or ſcar of the naval ſtring, by which it was faſtened to the ovary, and received its nouriſhment.
II. The coat caſt off by the ſaid ſeed.
B. The ſeed itſelf, that lay encloſed within the ſaid coat, of its natural ſize.
C. The ſame ſeed ſtripped of its coat, and magnified, ſo as to ſhew its little points and bivalved partition cleft, which divides the reſt of the body into two parts,
III. The young germe of the Clove-July-Flower.
IV. The ſame germe unfolded into leaves.
V. The caſe, or as it were the gem or bud of the Clove-July-Flower, which may be conſidered as the real Nymph of the vegetable.
VI. The Clove-July-Flower itſelf broken from its gem or bud, and in a condition to produce ſeed.

TAB. XLVII.

FIG. I.

The genitals of the male Frog, viewed with the microſcope.

a a The teſticles. *b b b b* The loins.
c Some of the appendages of the teſticles, conſiſting of oily or fatty bags.
d A ſingle appendage of the ſame kind.
e Others divided into two branches.
f Blood veſſels on the ſurface of the teſticle.
g g Globular heads or ends of the ſeminal teſticulary veſſels
h Some teſticulary veſſels, conſiſting of two parts.
i i Divided paraſtatæ, or ſeminal veſſels, by means of which the ſeed is forced from the teſticles into the common vaſa deferentia.
k k The manner in which theſe veſſels run under the membrane that encloſes the kidneys, and unite with the vas deferentia.
l l l l Vaſa deferentia lying round the loins.
m m A rough draft of the arteries diſtributed through the kidneys.
n n Two ſingular and ſtrange bodies ſeated at the kidneys, under the ſkin.
o o The place where the deferentia form on each ſide a ſingle trunk.
p p Seminal veſſels, or ſeed bags.
q q The ſtraight gut, into which the vaſa deferentia and ſeminal veſicles diſcharge themſelves.
r The orifice, or end of the ſaid parts.
s s The urinary bladder divided into two parts.

FIG. II.

All the foregoing parts, of their natural ſize.

FIG. III.

One of the ovaries, of its natural ſize.

a a Diviſions, or natural ends of the ovary.
b A braſs tube introduced into one of the little lobules of the ovary, in order to blow it up.
c c Eggs appearing through the membranes compoſing the ovary.
d One of the lobules of the ovary laid open, ſo as to afford a diſtinct view of the encloſed eggs.

FIG. IV.

The heart, liver, lungs, tubes, uterus, &c. in an impregnated female Frog.

a The ſkin with the ſternum and its cartilage drawn back over the head, and faſtened with a needle in that ſituation.
b The cavity, or hollow of the membranes, containing the heart, and formed under the breaſt

breaſt bone by the concretion of the peritoneum, and the ligament by which the liver is ſuſpended.
c c Natural openings of the tubes, growing againſt the membranes already taken notice of, which extend over the heart, and its pericardium.
d d That part of the tube which makes a great many beautiful windings and foldings.
e The blood veſſels of the tubes.
f f The extremities of the tubes, near or about the ſides of the uterus.
g g The uterus, conſiſting of two parts.
h The ſtraight gut in its natural ſituation.
i The urinary bladder, conſiſting of two parts, in its natural ſituation.
k The contracted ovary, in which there ſtill remains one perfect egg.
l Part of the left kindey, upon which the ovary lies, and at whoſe ſide lies the vein of the kidney.
Appendages of the ovary ſupplying it with oil.
n Two eggs floating freely in the belly, near the tubes
o An egg in the tube itſelf.
p The ſtomach contracted, in its natural ſituation.
q One of the tubes of the liver.
r The gall bladder.
s s The lungs; the left one contracted.
t t The auricle of the heart.
u u u Parts of the thorax and abdomen cut off.

FIG. V.

The manner of finding the eggs diſperſed in the Frog's belly, when in their paſſage through the tube into the uturus.

a Some little eggs in the ovary.
b b b Some eggs, ſcattered up and down the belly.
c Six eggs cloſe to the tube's mouth.
d d d Eggs in the tubes.
e An egg in the tube, near its mouth.
f f Some eggs, preſſing through the extremities of the tubes, into the utrus.
g The manner in which the eggs appear faintly through the uterus.
h The manner in which the eggs appear diſtinctly through the uterus, after it has been for ſome time expoſed to the open air.
i The extremity of the double uterus, which opens into the ſtraight gut, about an inch from the place where the tubes empty themſelves into the uterus.
k The origin or beginning of the great artery, with the auricle and heart.
l l Natural openings of the tubes.
m m The lungs in their natural ſituation, in part covering the tubes.

FIG. VI.

A microſcopical view of the fore legs or arms of the male Frog.

a The thick thumb.
b Black papillæ, with which it is covered.

TAB. XLVIII.

FIG. I. and II.

The manner in which the Frogs copulate.

a a The manner in which the male embraces the female, with his arms, and as it were folds his fingers between one another.
b b The manner in which the head of the male, lies over the head and between the eyes of the female.
c c The drum of the ear, covered only with the external ſkin.
d The manner in which the female ejects her eggs.
e The manner in which the male pours out its ſeed upon them.
f The manner in which the eggs flow together in a circular form.

FIG. III.

A microſcopical view of the ovary and its appendages.

a a Some eggs, *b* Larger eggs.
c d Eggs becoming imperceptible by degrees.
e Blood veſſels interwoven with the eggs
f A perfect egg, about to diſappear in the ſame manner

FIG. IV.

A cluſter of eggs magnified.

a a a Hollow membranes, or little membranes full of cavities, in which the eggs lie.
b b Blood veſſels belonging to the ſaid cluſter.
c c The main trunk of the blood veſſels.

No. 1. *to* 10.

The ſlow increaſe or growth of the eggs.

1 A Frog's egg newly depoſited.
2 Another, a day old.
3 Another, two days old.
4 Another, three days old, as expreſſed in four different drawings.
5 Another four days old.
6 The fœtus of the Frog, as it appeared the next day.
10 The ſame viewed on the tenth day from the laying of the egg.

FIG. V.

A microſcopical view of the fœtus of the Frog in an egg newly depoſited, and diveſted of its white.

a a A furrow in the middle of the Frog's body.
b b Remains, or rather rudiment, of a yellow ſpot, which appears in the ſkin of theſe creatures, even before they are hatched.

FIG. VI.

The ſame fœtus broken into two parts.

a A protuberance in form of a creſcent, viſible on the internal ſurface of one of the ſides; in this place the furrow penetrates to a conſiderable depth.
b A little hole or cavity in form of a creſcent, ſerving to receive the foregoing protuberance.
c c The place where the furrow is very ſhallow.
d d The ſurface of the fraction, ſhewing the Frog's body to conſiſt of globular, or ſpherical grains or particles.

FIG. VII.

A microſcopical view of the young Frog, within its chorion and amnion.

a A ſide view of the Allantoies, with the chorion and amnion which entirely encloſe the fœtus.
b The furrows already taken notice of.
c Superficial clefts of the yellow ſpot, obſervable in the Frog's egg.

FIG. VIII.

The ſame parts, but in another ſituation.

a The coat, called the allantoies dilated.

FIG. IX.

Another repreſentation of the ſame parts.

a The allantoies or coat, ſtretched out into the ſhape of a pear.

FIG. X.

The ſame parts again, with the foregoing coat extended to its greateſt ſize and bulk.

FIG. XI.

The fœtus of the Frog, as it appears fourteen days after the laying of the egg.

FIG. XII.

A microſcopical view of the ſame fœtus.

a a The eyes. *b* Its wide mouth.
c c Fimbricated appendages, which in proceſs of time are taken in by the body, where they conſtitute the gills.
d The extremity of the extius of the inteſtine, which forms ſome windings and protuberances in the belly.
e e The tail, of a fleſhy ſubſtance in the middle, but membranaceous at the edges.
f The extremity of the muſcular and cartilaginous part of the tail.

FIG. XIII.

The fœtus of a Frog, thirty-ſix days after the laying of the egg, exhibing very diſtinctly its head, two hinder legs and tail.

a The aperture or opening of the mouth.
b The hinder legs and tail.

TAB. XLIX.

FIG. I.

The fœtus of the Frog repreſented by Fig. XIII. of the laſt Table, diſſected, and viewed with a microſcope.

a a The lower jaw-bone, of a black horny ſubſtance, and furniſhed with teeth.
b The upper jaw-bone.
c c White papillæ ſurrounding the mouth.
d d A portion of the protuberant eyes.
e e Four rows of gills on each ſide.
f f The lungs, one of which is inflated, the other collapſed.
g The heart. *h* Its auricle.
i The liver and vena cava.
k The gullet. *l* The gall bladder.
m The winding of the gullet about the liver.
n Part of the meſentery, with its blood veſſels.
o The ſtomach in the beginning of its growth.
p The pancreas in its natural ſituation.
q The ſmall gut.
r r Very beautiful double foldings of the inteſtines.
s The ſtraight gut. *t* The podex.
u u The two hinder legs, which grow beyond, or on the outſide of the body.
x x The fore legs, which lay hid under the ſkin. *y y y* Muſcles of the tail.
z z The membranaceous ſkin of the tail.

FIG. II.

The manner in which the Tadpole caſts it ſkin.

a The ſmall opening of the mouth, in the ſkin caſt by the Tadpole.
b The wide mouth of the Frog.
c c The two fore legs, which heretofore lay hid in the breaſt, under the ſkin, now diveſted of it. See Tab. XLVI. No. V. letters *k k*.
d d The two hinder legs on the point of dropping their ſkins.
e e Pulmonary veſicles, which nature has beſtowed on the male only.

f f Two

f f Two thick thumbs, proper likewiſe to the male.

FIG. III.

The Frog's arteries.

a The heart.
b The auricle, over which lies the origin of the great artery that iſſues from the Frog's heart.
c One of the two main trunks of the great artery, which is like the ſubclavian vein, and runs towards the right ſide of the thorax.
d The other main aſcending trunk, running to the left ſide.
e e Arteries of the lungs, which they only ſerve to nouriſh. I have here exhibited three branches of them, cut off.
f f Two minute arteries, iſſuing from the lungs, and running towards the parts of the mouth.
g g Two arteries, each of which ſwells into two knots.
h h Two very conſiderable branches of the arteries, which ariſe from the aſcending trunks of the great artery, then take a circular turn, and at length unite in the loins.
i i The axillary arteries.
k k The carotide arteries.
l l The arteries of the vertebræ.
m That of the meſentery.
n n That of the loins.
o o Thoſe of the teſticles, and ovary.
p Thoſe of the kidneys.
q q The iliac branches.

FIG. IV.

Veins of the Frog.

a a The upper trunks of the vena cava.
b The place where the arteries are cut away.
c c The place where the pulmonary veins are likewiſe cut away.
d d Veins running to the parts of the mouth.
e e Others running to the head.
f f Two veins, running to the muſcles of the fore legs.
g g Axillary veins.
h h Two conſiderable branches, which run into the ilia under the ſkin.
i i The trunk of the vena cava, on the back.
k k The vena cava in the liver.
l The vein of the meſentery.
m The emulgent or kidney veins.
n n The iliac.
o o The epigaſtric vein, running double at its origin.

FIG. V.

The motion of the muſcles in a Frog.

a a Two tendons of a muſcle, held by the fingers.
b The dependent nerve of it, irritated; by means of which the muſcle contracts itſelf, and ſo draws towards itſelf, the two hands holding the tendons.

FIG. VI.

The manner in which the thickneſs of the muſcle increaſes, during the contraction of the muſcle.

a A glaſs tube, through which the muſcle is paſſed.
b b Two pins run through the tendons of the muſcles.
c The irritated nerve, by which it comes to paſs that the pins *b b* are forced from their places towards *d d*, and that
e The muſcle, in conſequence of its contraction, fills the middle of the tube.

FIG. VII.

The manner in which the heart, during its contractionss takes up leſs room, and leſſens in bulk.

a The heart, contracting itſelf within a ſyphon or glaſs tube, upon whoſe piſton it lies.
b b A glaſs tube.
c A drop of water, adhering to the inſide of the tube, which drop deſcends while the heart contracts itſelf.
d The part of the tube, ſhewing how low the drop of water *c* falls at that time.

FIG. VIII.

The manner in which the muſcle, at the time of its contraction, comes to occupy a ſmaller ſpace.

a The glaſs tube, or ſyphon
b The muſcle.
c A ſilver wire with a ring in it, through which the nerve paſſes.
d A braſs wire, with a ring on the upper end of it, through which the ſilver wire paſſes.
e A drop of water in the glaſs tube.
f The hand that irritates the nerve, in conſequence of which irritation the drop on the muſcle, contracting itſelf, deſcends a little.

FIG. IX.

The ſame experiment, ſhewn after another manner.

a The glaſs tube.
b A little hole bored in the tube.
c The nerve ſtretched through the ſaid hole.

TAB. L.

The hiſtory of the Cuttle-Fiſh.

FIG. I.

The external parts or limbs of the Cuttle-Fiſh, laid

laid flat on its belly, ſomewhat leſs than nature.

a a The two thickeſt and broadeſt of the Cuttle-Fiſh's eight legs.

b White furrows on the purple ground or ſkin of the legs.

c c c The acetabula, or hollows like ſaucers, with their ſtalks, pediments or muſcles, of which there is a ſurpriſing number diſtributed all over the eight legs.

d d Origins of the arms of the creature, in their natural ſituation.

f f f The looſe membranaceous and muſcular ſkin of the eight legs, with which ſkin the acetabula are covered, when the Cuttle-Fiſh faſtens itſelf to any place.

g g Places of the legs where the acetabula are very ſmall, but have notwithſtanding the benefit of the ſkin.

h h A more diſtinct view of the ſaid muſcular ſkin near the extremities of the arms; and likewiſe of the manner in which it ſerves to cover the acetabula.

i The Fiſh's ſnout, or beak, formed like that of a Parrot.

k Fleſh, which ſurrounds the ſnout or beak, like lips or gums.

l l The eyes, of an extraordinary ſize.

m m The tranſparent cover of the eyes, or eye-lids.

n The prominent point of the back.

o o o o The ſoft and muſcular part of the Cuttle-Fiſh, on each ſide of its back.

p The place, lower down, where it is divided into a right and left ſide.

FIG. II.

The conſtruction of the acetabula, the muſcles and rings of their natural ſize.

1 A muſcle in the centre of the acetabulum, as likewiſe the manner in which this part is entirely compoſed of muſcular fibres. On the upper part may be ſeen the black edge of of a horny bone, in form of a ring, of conſiderable ſervice in the conſtruction of this organ.

2 The internal cavity of the acetabulum, its fibrous and muſcular ſtructure, as likewiſe the black edge of the ring, juſt now mentioned. Lower down is to be ſeen that part of the muſcle, which ſerves to dilate the acetabulum.

3 The ring, already exhibited by its ſelf, placed on its ſide.

4 A front view of the ſaid ring.

5 Part of the ſaid ring cut off.

FIG. III.

The conſtruction of the ſnout or beak, of its natural ſize.

a a The wings of a horny bone, compoſing the lower part of the beak or ſnout.

b b The place where the beak or ſnout is bent upon itſelf, ſo as to acquire both firmneſs and thickneſs.

c The place where the ſaid bent back part of the ſnout or beak turns, and runs forward again, and forms a hollow cavity.

d The upper part of the ſnout or beak, which differs very little from the lower in point of conſtruction or ſhape.

e e Its internal hollow, containing the tongue.

FIG. IV.

The tongue, and ſalival ducts, of their natural ſize.

a A natural bending, or inflection about the cartilaginous bones of the tongue.

b The muſcular fleſh of the tongue, of a ſpungy or fungous ſubſtance.

c The mouth of the ſalival duct, in the muſcular part of the tongue.

d The ſalival duct itſelf.

e e Two glands, from which the ſalival duct takes its origin.

f f Some of the muſcles belonging to the tongue.

FIG. V.

The tongue by itſelf, of its natural ſize.

a The unequal membrane of the tongue.

b Seven cartilaginous bones of the tongue, ſeparated from each other at their extremities.

FIG. VI.

A microſcopical view of part of the cartilaginous bones of the tongue.

a Cartilaginous papillæ, ſituated on the ſaid bones.

FIG. VII.

A microſcopical view of the tongue, inverted.

a a Part of the root of the tongue, where its bones appear through the microſcope, in form of a regular piece of net-work.

TAB. LI.

FIG. I.

The internal parts of the Cuttle-Fiſh, that may be ſeen, without any diſſection, by juſt removing the looſe muſcular covering of the belly.

a a The muſcular covering of the breaſt and belly, cut off.

b b The place on the declivity of the belly, where the ſaid muſcular fleſh was cut off.

c The place near the tail, treated in the ſame manner.

d The lower part of the common excretory bag like an inverted funnel.

e The upper part of the ſaid bag, narrower.

f f Two oval hollow parts, united to the excretory bag.

g g Two conſiderable prominencies or papillæ, adhering to the looſe muſcular part of the abdomen. Theſe prominences fill up, while the creature lives, the hollow parts juſt now mentioned.

h h Two oblong and ſtraight muſcles, which ſerve to move the acetabula, that are, as it were, ſupported by them towards the papillæ, and draw them back again.

i i The gills, and their blood-veſſels, ſituated at each ſide of the abdomen, and at a great diſtance aſunder.

k Diviſions of the blood-veſſels in the lamellæ, or plates of the gills, extended on the inſide to their roots.

l l The place where the lamellæ of the gills terminate in a ligament, which ligament might very eaſily be taken for a blood-veſſel.

m The ſame more diſtinctly exhibited; as likewiſe a view of the diviſions of the blood-veſſels in the lamellæ of the gills.

n A tranſparent part, called *mutis.*

o The extremity of the ſtraight gut, which floats in the abdomen, like a hollow tube.

p The tranſparent ink--bag, which likewiſe diſcharges itſelf into the abdomen.

q q Two tubular apertures, or openings, beneath the ſtraight gut, and near it, by which the ſeminal matter is emitted.

r The place where there lie deeper, under the other parts, the veſſels in which the ſeminal matter is prepared.

s The tranſparent ſtomach.

t A tranſparent particle, in form of a heart, belonging to the ſpermatic parts.

u The extremity of the vaſa differentia of the teſticle, floating likewiſe freely in the abdomen.

x The tranſparent teſticle.

y Some arteries, which run to the muſular parts of the ſkin. Their fellows are to be ſeen on the other ſide of the body.

z Tranſparent nerves, which appear in great numbers through the ſkin, both there, and and at the other ſide.

α The muſcular circle of the mouth.

β β The arms, cut off.

γ γ The order obſerved by the acetabula during the contraction of the muſcles.

δ δ The internal conſtruction of the broadeſt and largeſt of the eight legs.

ε ε The two eyes.

F I G. II.

A very diſtinct view of the muſcles of the ſmalleſt acetabula, in their natural ſituation and ſize, as they appear on the extremity of one of the arms, ſeparated from the reſt.

a The conſtruction and ſituation of the muſcles of the acetabula.

b The manner in which the acetabula are united with their muſcles.

c d The place where the muſcles are ſhorteſt and ſmalleſt, being where the rows of acetabula begin and terminate.

F I G. III. and IV.

The body, called mutis, *a little leſs than nature.*

a a Its upper part, which is very thick, and may be divided on each ſide into two lobes.

b b Its obtuſe appendages, in which the lower part of it terminates.

c c Two arteries, iſſuing from the great artery, and running to or ſupplying the right and left ſides of the mutis.

d A membrane ſeparated, and turned back from the mutis, in order to give a view of it internal veſſels.

e The courſe of the veſſels, exhibited apart.

f f A granulated ſubſtance, of which the mutis is principally compoſed.

F I G. V.

The gullet, ſtomach, ſtraight gut, pancreas, and excretory duct of the Ink.

a The jaws.

b b Salival glands, in their natural ſituation. The gullet runs lightly over theſe glands, in its way from the jaws to the ſtomach.

c The ſtomach.

d The blood-veſſels of the ſtomach.

e The ſtraight gut.

f The pancreas, beautifully wound into a ſpiral form.

g The bladder, ſerving to force out the ink.

h The duct of the ink from the ſaid organ to the extremity of the ſtraight gut.

i Th blood-veſſels of the ink-bladder or bag.

k k k A glandulous body, whoſe uſe is not yet diſcovered.

F I G. VI.

A piece of the Cuttle-Fiſh's bone.

a A great number of little lamellæ or plates, compoſing the bone. The uppermoſt are the largeſt, and lie cloſeſt to each other.

b The hard cruſty covering of this bone. The lamellæ or plates that are neareſt to this cruſt are the ſhorteſt, and likewiſe at the greateſt diſtance aſunder, ſo as to afford a more ſatisfactory view of the little columns that ſupport them, one above another.

F I G. VII.

A microſcopical view of two of the lamellæ, or plates, and their interjacent columns.

c The beautiful order in which the columns are placed between the teſtaceous ſhelly lamellæ or plates.

d The firſt or upper lamella or plate, in which appear the marks of the columns, broken away from it.

e The lower or ſecond plate.

f Some tranſverſal fibres of a ſhelly ſubſtance, which bind the columns together, and thereby add conſiderably to their firmneſs.

FIG. VIII.

Some of the plates, juſt now exhibited, removed from the columns that ſupported them.

g Their hollow tubular conſtruction, in conſequence of which they muſt naturally contain a portion of air, and of courſe the bone can ſwim on the ſurface of the water.

FIG. IX.

The tail of the Cuttle-Fiſh's bone, drawn after nature.

h A ſharp point, thro' which the Cuttle-Fiſh's bone grows out.

i i The membranaceous parts on each ſide.

k The place where the piece of bone, under our conſideration, was broken off from the reſt of it, ſhewing ſome beautiful globular eminences, which firſt hardened into a ſtony bone above the reſt of the ſurface.

TAB. LII.

FIG. I.

The heart and arteries of the Cuttle-Fiſh, of their natural ſize.

a The heart.

b b The double auricle of the heart.

c c Part of the largeſt blood-veſſels belonging to the gills, from which the auricles are ſeparated. *d* The great artery.

e e Its two branches, running to the body of the mutis, while others proceed further.

f Arteries extended to the baſe, or root of the brain, where they are afterwards diſtributed.

g g Two blood-veſſels, iſſuing from a lower part of the heart. They are full of veins.

FIG. II. III. and IV.

The brain, nerves, and eyes, of their natural ſize.

a The brain.

b Fat lying near the brain, repreſented by dots.

c c The optic nerves, whoſe origens are likewiſe inveſted with fat.

d d Knotty dilatations of the optic nerves.

e e e e Nerves ſent in great numbers from the ſaid nodules or knots to the eyes.

f A blood-veſſel, that interſects the nerves running to the eyes.

g A great many little nervous fibres in the choroides of the eye.

h The place where the ſaid coat converges a little more in form of a globe about the cryſtalline lens, and thereby forms the iris of the eye.

i A portion of the cryſtalline lens, projecting beyond the eye.

FIG. III.

k The cover of the pupil, on that ſide where I cut it off from the eye.

l That ſide of the ſaid cover, which floats freely in the aqueous humour.

FIG. IV.

m The manner in which the cryſtalline lens is divided to a great depth by the ciliary ligament.

FIG. II.

11 22 23 Three pair of nerves iſſuing from the brain, the middlemoſt of which is beautifully dilated into a nodule.

n All theſe nerves are diſtributed amongſt the fore parts of the head.

o o Cartilages encloſing the brain.

p p Cartaliginous expanſions, in which the muſcles of the legs are placed, and in the middle of which the head and ſnout, or beak of the Cuttle-Fiſh, is placed.

q q Two ſtrong nerves, which iſſue from the bottom or root of the brain on its hinder part.

r r Two nodules, which theſe nerves form in the breaſt, and from which great numbers of nerves run to the lower parts of the Cuttle-Fiſh's body.

FIG. V. and VI.

The teſticle and its parts, of their natural dimenſions, viewed on each ſide.

a Some little white bodies, which I found hanging in this creature on the outſide of the vas differens.

b The pointed extremity of the teſticle.

c The corpus variciforme of the teſticle.

d Its extremity, as far as I have as yet been able to trace it.

e The place where the paraſtatæ are moſt ample and ſpacious, as may be ſeen in the teſticle, turned upon its other ſide.

FIG. VI.

f Some other minute extracted from the teſticles, which was full of them. Theſe parts are all looſe in the hinder part, without the leaſt faſtening.

g Some fine filaments, in which the ſaid minute parts terminate on their fore ends, and by means of which they are there connected together.
h The manner in which a white ſubſtance, that curls itſelf in a ſerpentine form, iſſues from the ſaid minute parts.

FIG. V.

i i The manner in which theſe white minute parts appear thro' the teſticle, and wind themſelves in a ſerpentine manner, while as yet encloſed in it.

FIG. VII.

A microſcopical view of one of theſe minute parts.

a Its hinder part, looſe and tranſparent.
b A white ſubſtance encloſed in the ſaid part, and which is forced out of it by the water that penetrates it.
c Places where it is tranſparent at each end.
d Beautiful windings of the ſame on its fore extremity.
e e Its fine, delicate, or ſlender filament, which hardens in the open air like the Silk-Worm's thread.

FIG. VIII.

Two pair of glandular bodies, belonging to the ſeminal veſſels, of their natural Size.

a a The firſt pair of theſe white bodies, cut off from the gills.
b b The ſecond pair of gladular bodies of a gray colour, in other reſpects like the firſt pair, with which they are connected by means of two glandular tubes.
c c A glandular body ſituated between the two pair juſt deſcribed.
d d Some tender membranes, which bind together the ſaid body and its lobules.

FIG. IX.

A third particle belonging to the ſeminal veſſels, of its natural ſize.

a Its figure on the upper part, where it is pretty flat.
b Its figure on the lower part, where it is ſomewhat ſharp, with a diviſion in the middle, that gives it in ſome meaſure the reſemblance of a heart.

FIG. X.

The genitals of the female of their natural ſize.

a The ſtraight gut.
b The duct of the organ ſerving to preſs out the ink.
c The ink-bag itſelf.
d d The ovary.
e The duct by which the eggs are diſcharged.
f Three eggs. *g g* Two glandular bodies.
h A peculiar part containing a reddiſh humour.
i i The gills in their natural ſituation.

TAB. LIII.

The ſeeds of the Fern.

FIG. I.

Part of a Fern leaf, with its tubercles.

a a An indented or jagged leaf of the Male Fern of Dodoneus, reſembling the feather of a bird.
b b Tubercles of a Fern leaf compoſed of ſome leaves, and a great many little pods which contain the real ſeed of the plant.

FIG. II.

Five of the ſame kind of pods of their natural ſize, and viewed different ways.

c c c Three pods with ſingle ſtalks.
d One with a double Stalk.
e e e The place where the ſtalk ſurrounds or girds the pod, as it were like a twiſted cord in form of a crown.
f f The manner in which the pod ſwells beyond the ſaid twiſted cord on each ſide of it.
g A pod placed in the center of the ſurrounding cord; as likewiſe the place where the pod firſt begins to open.
h h The cord reduced to a ſtraight line by ſome elaſtic power.
i i i i The pod burſt in two, ſo that the parts now conſidered in themſelves form as it were four hollow cups.
l The membrane of the pod broke open, and turned back upon the coronal cord of the ſtalk that ſurrounded the pod, ſo as to afford a view of the encloſed ſeeds in their natural ſituation. But it is by great chance that a pod opened in this regular manner can be met with.

FIG. III.

The ſeed.

k Five out of forty-one ſeeds, that I found in one pod, magnified to a very great degree.

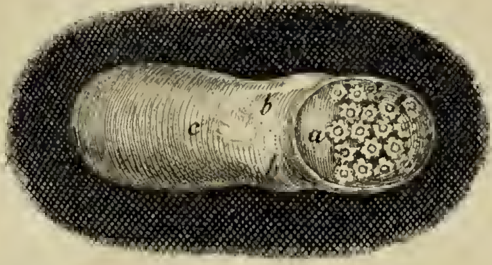
The END of the Explanation of the TABLES.

Order the First
Nymph = Animal.

TAB: I.

I

Fig: I.



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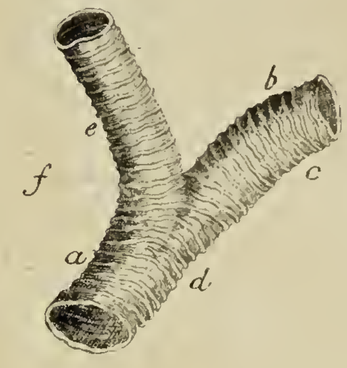

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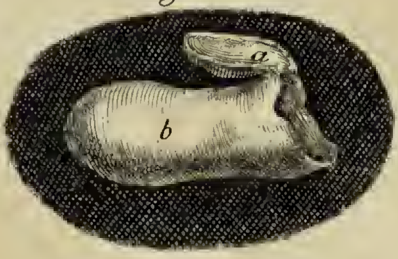

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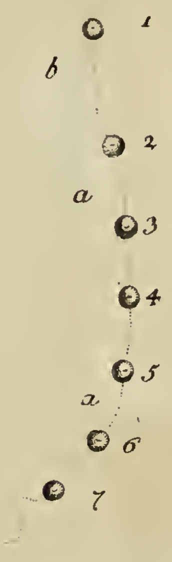

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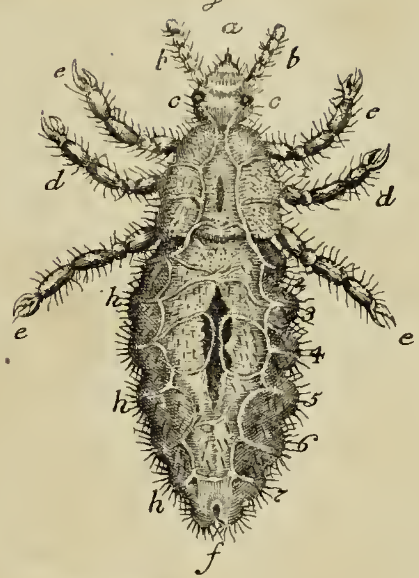

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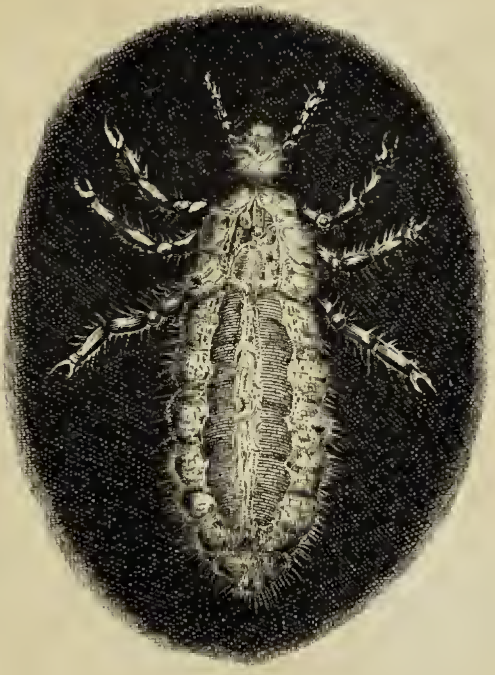

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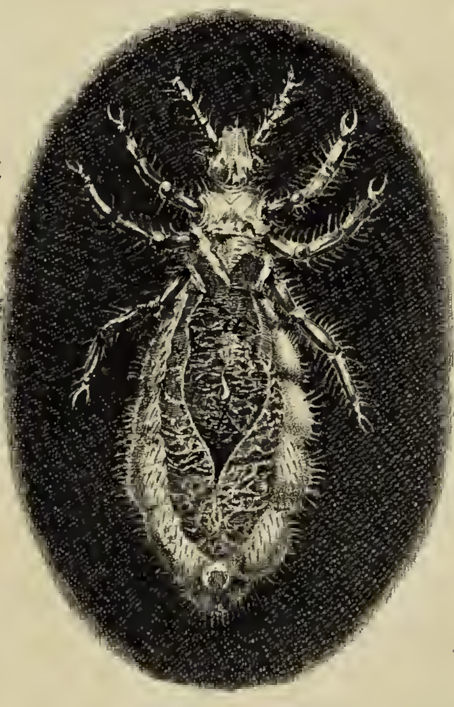

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Fig: V.

J.C.G. Fritzsch. sc:

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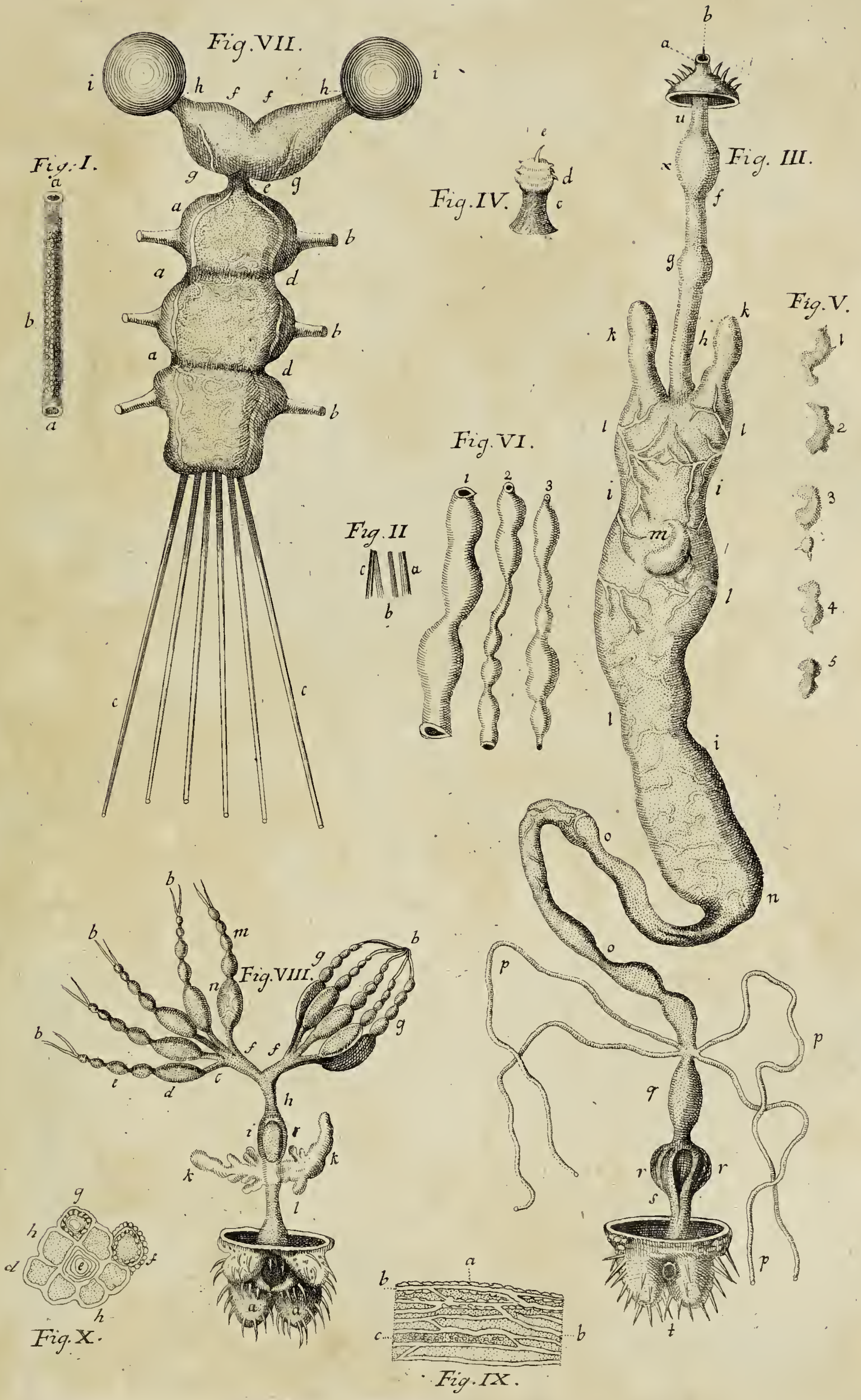
Fig. VII.
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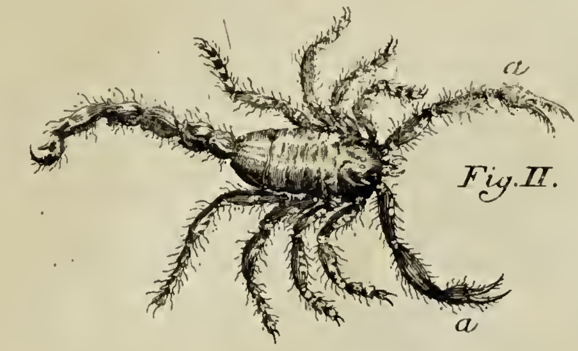
Fig. IX.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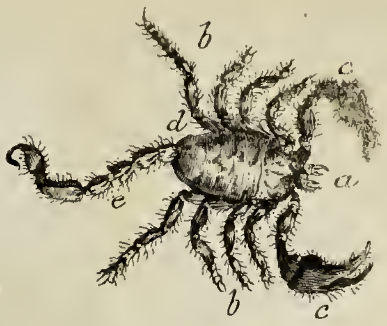
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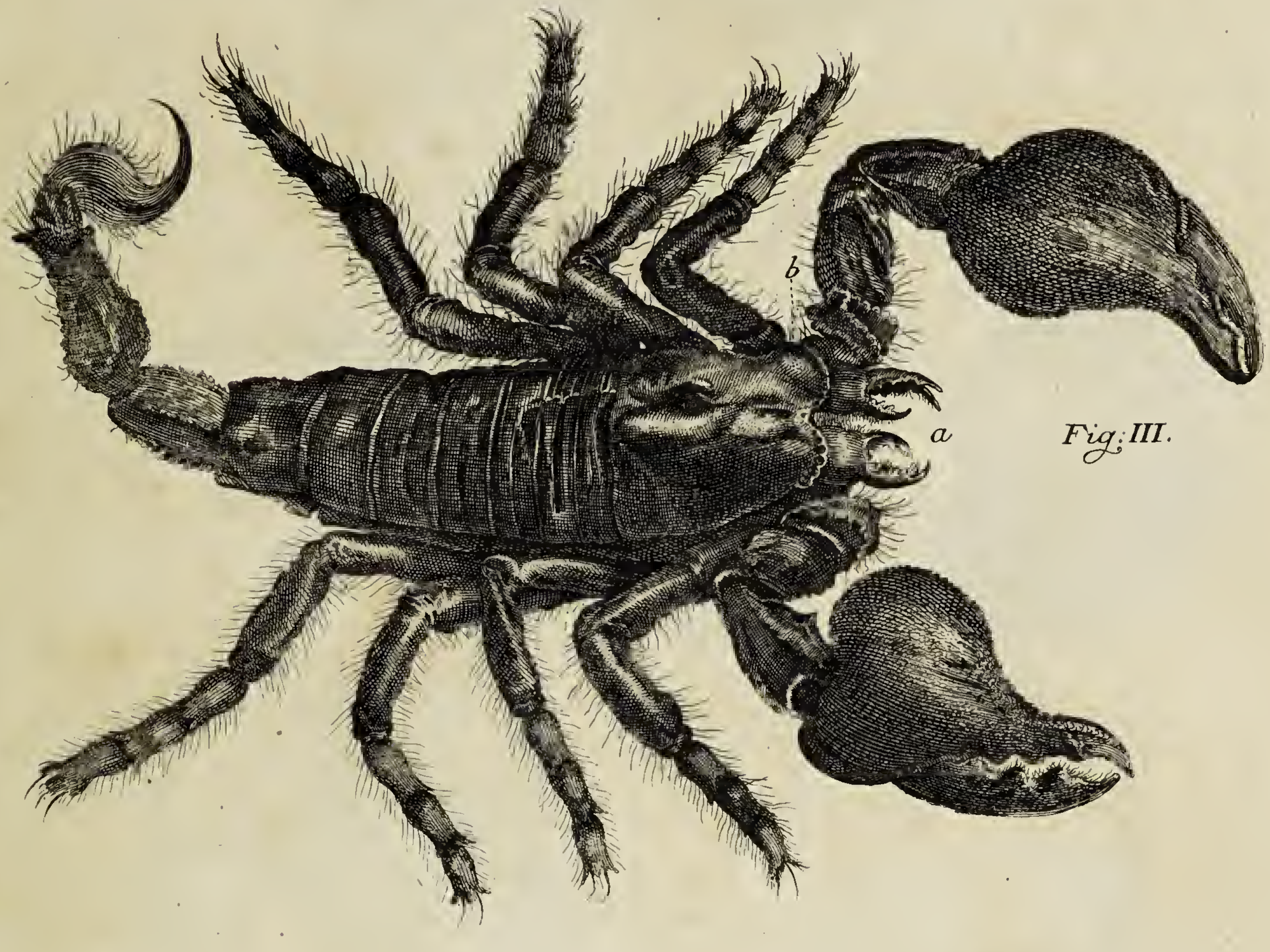
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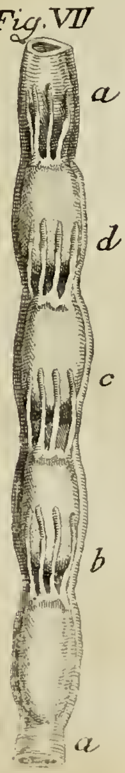
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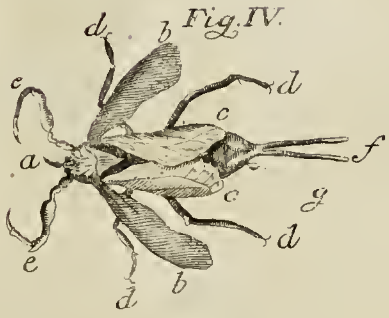
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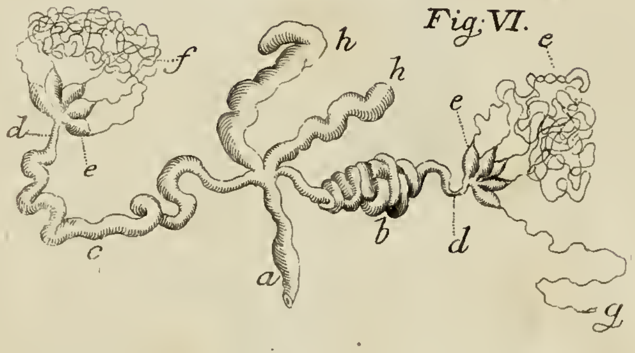
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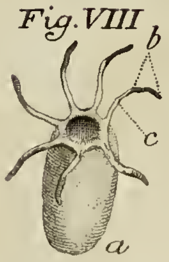
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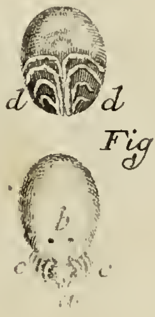
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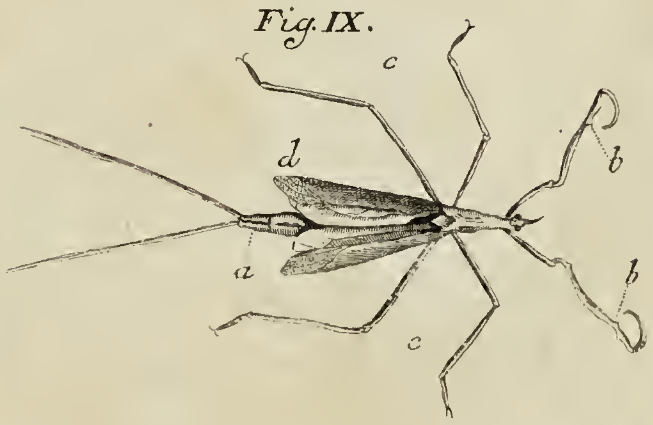
Fig.IX.

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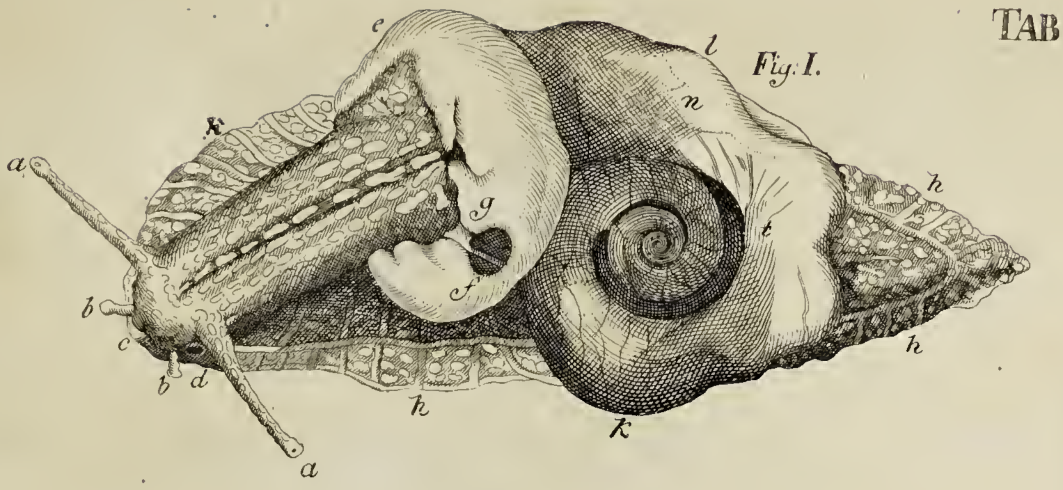
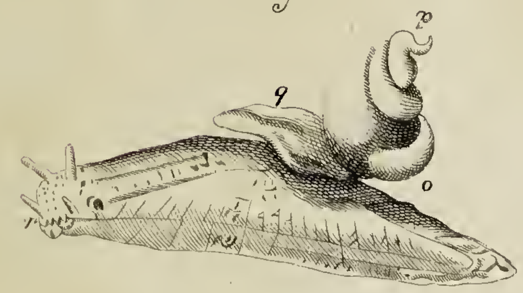


Fig. I.

Fig. IV.



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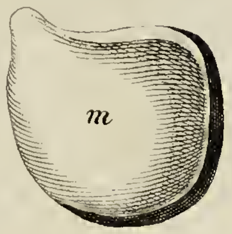

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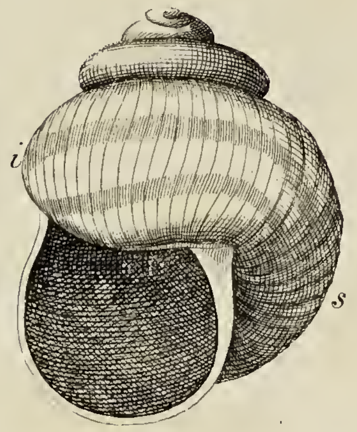

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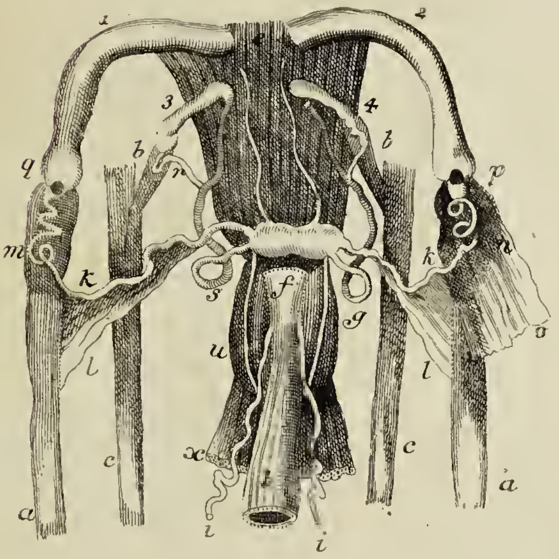

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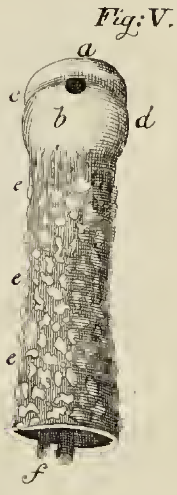

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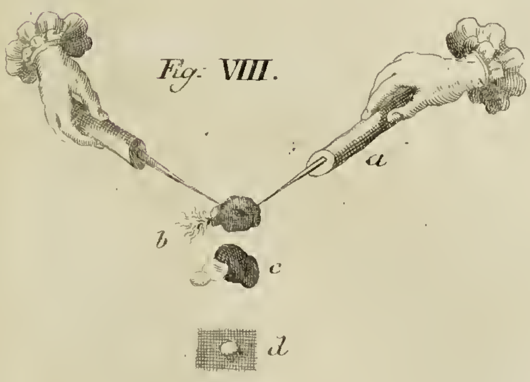

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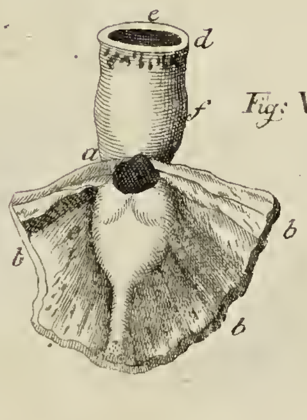

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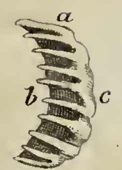
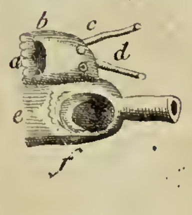


Fig. I.



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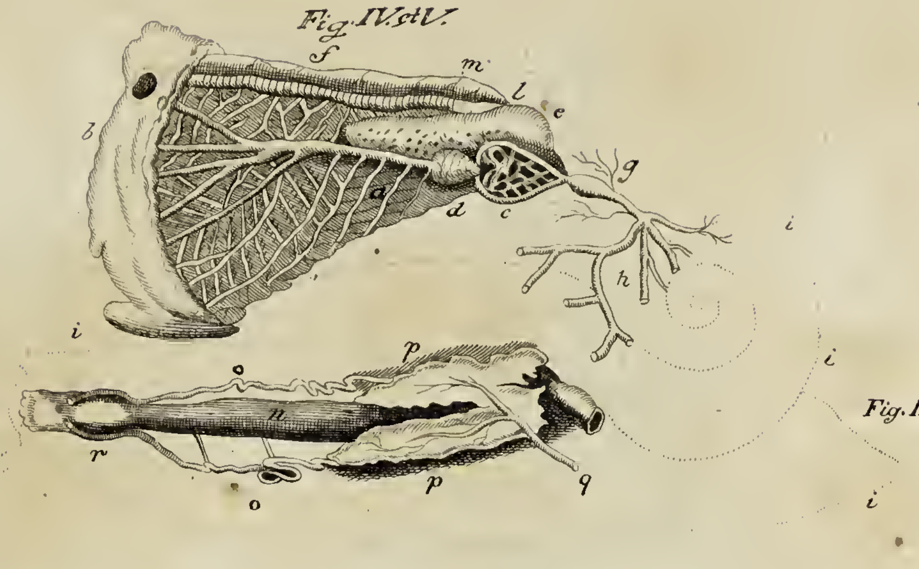

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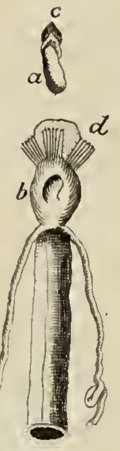

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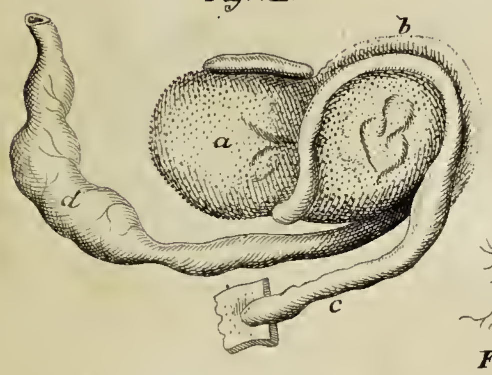

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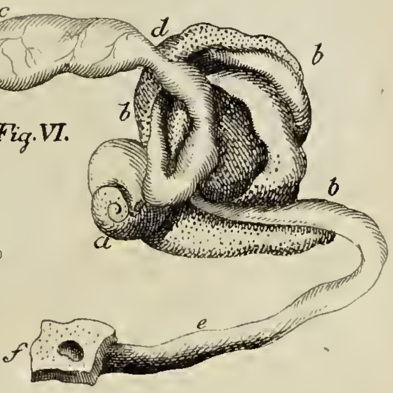

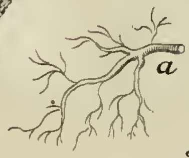

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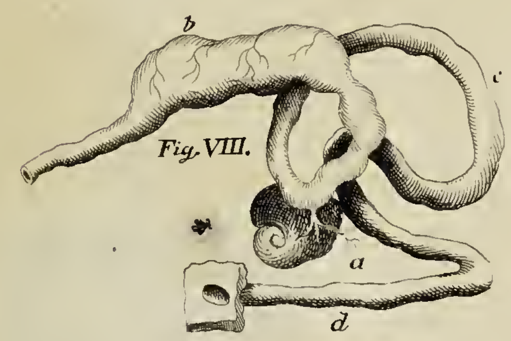

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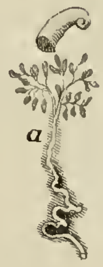

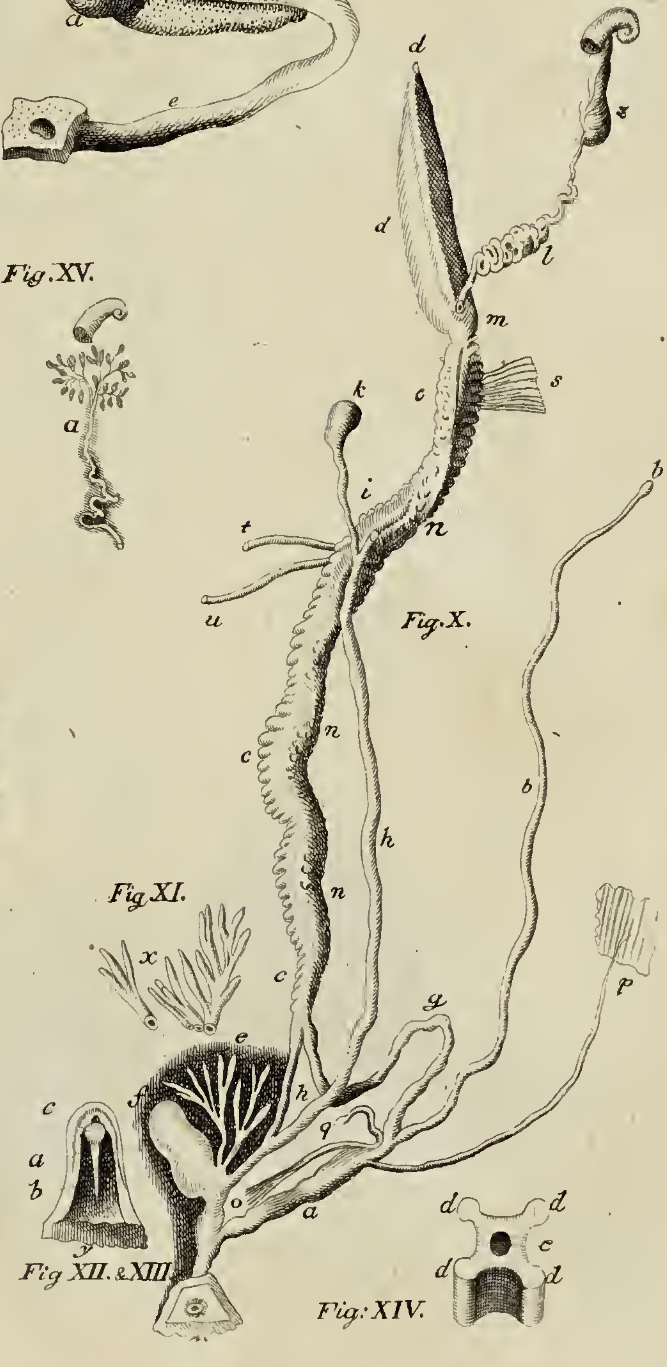

Fig. X.

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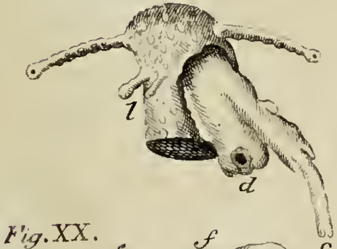

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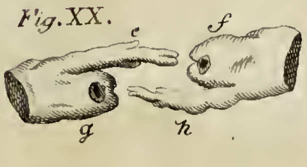

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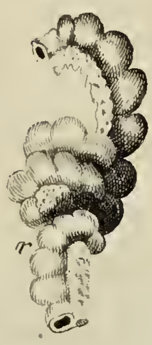

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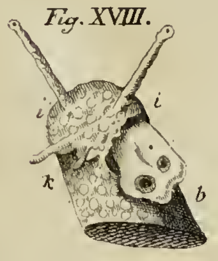

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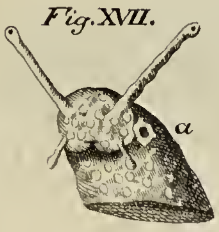
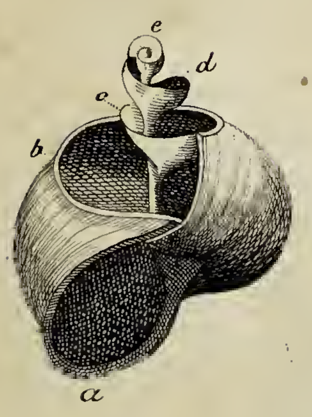


Fig XII. & XIII.

Fig: XIV.

Fig.III.



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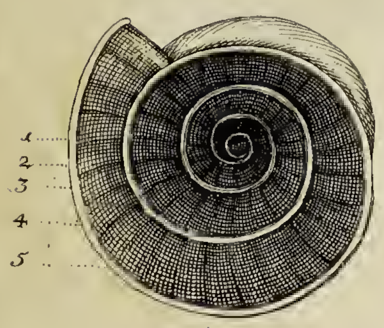

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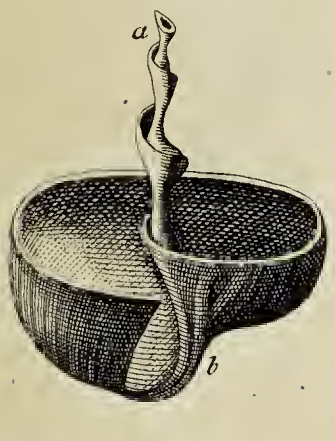

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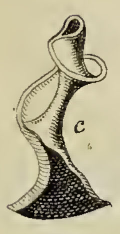

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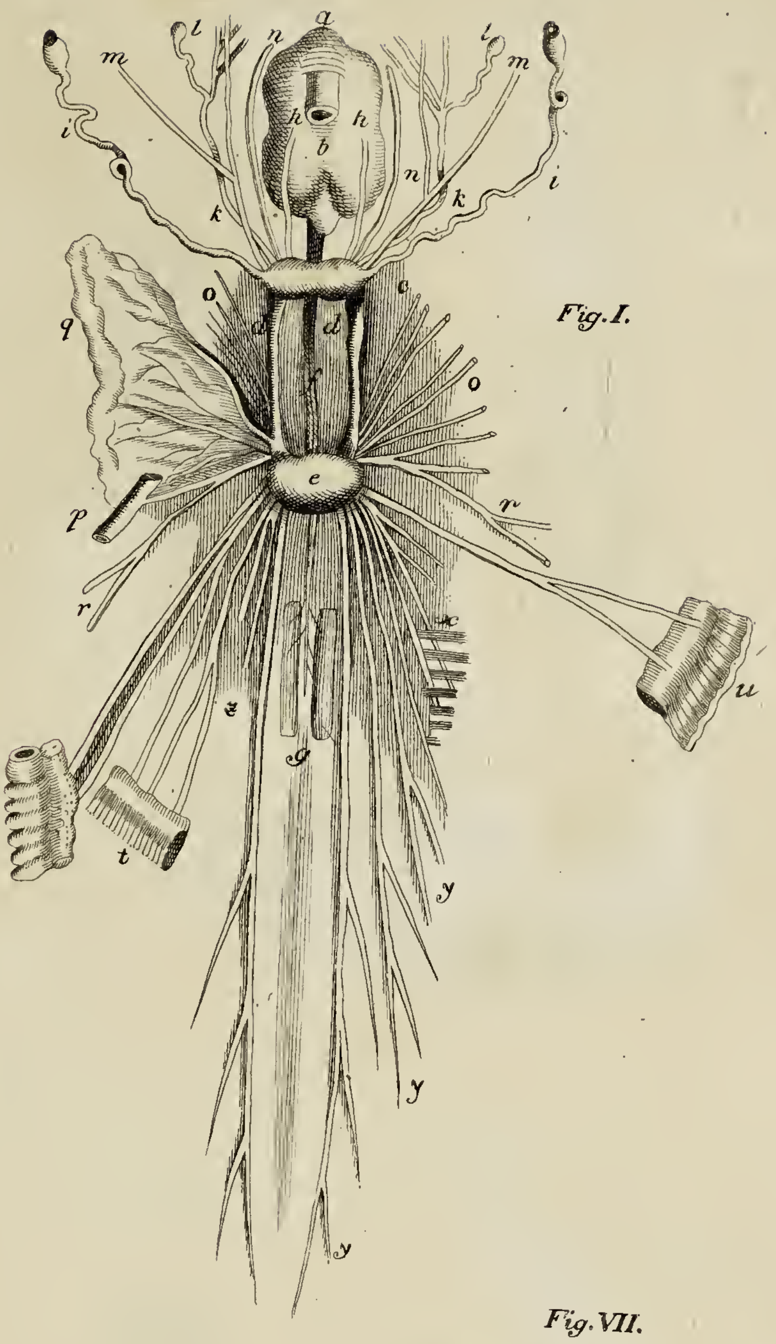

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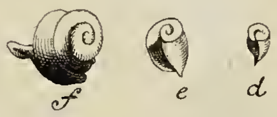

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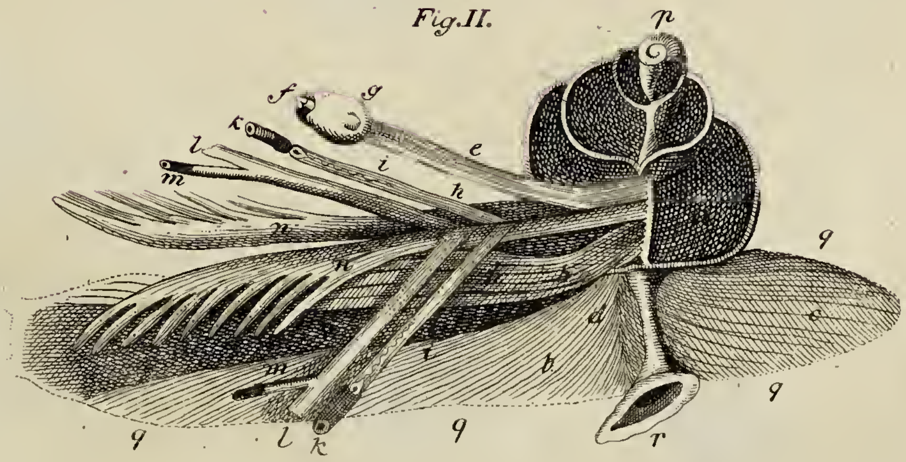

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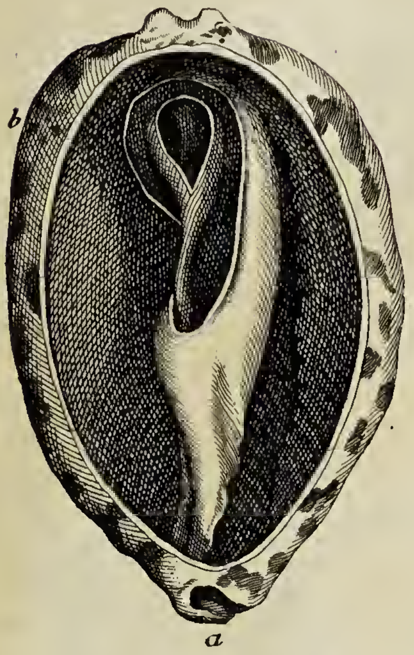

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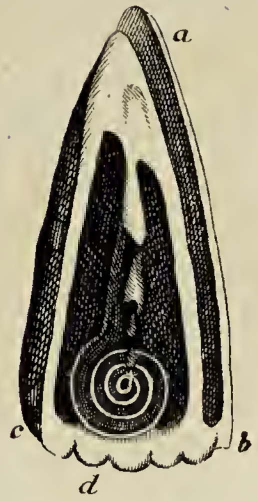

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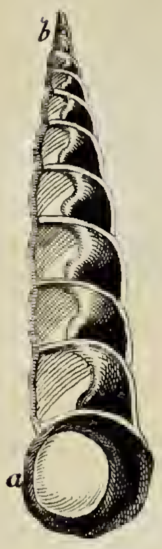

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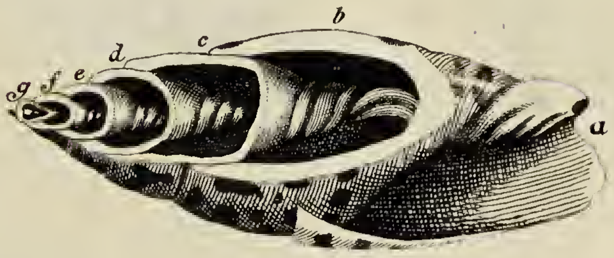

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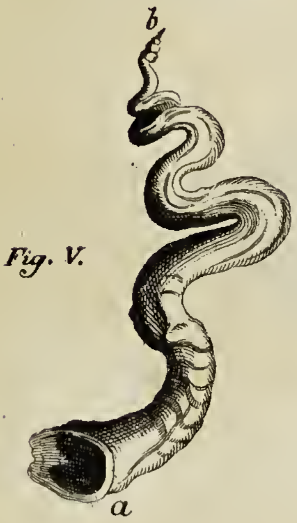

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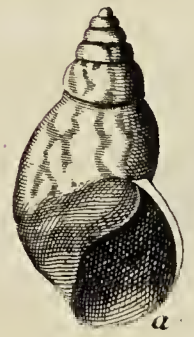

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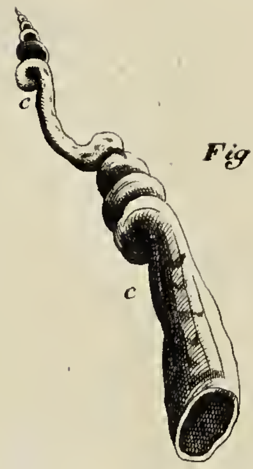

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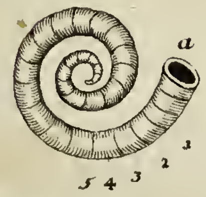

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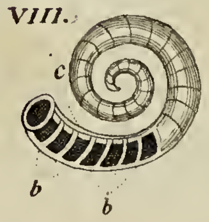

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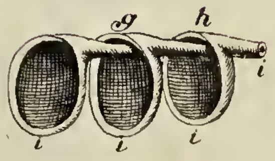

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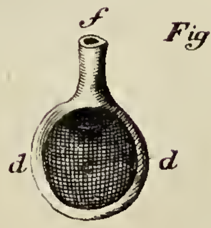

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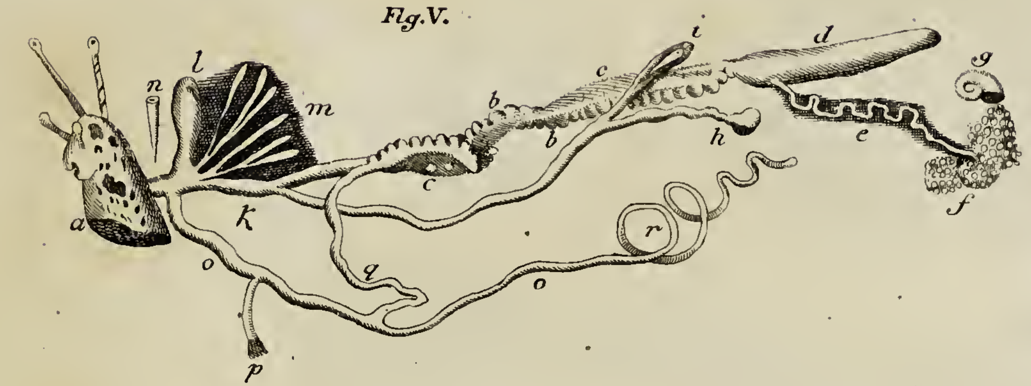

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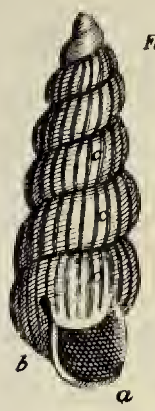

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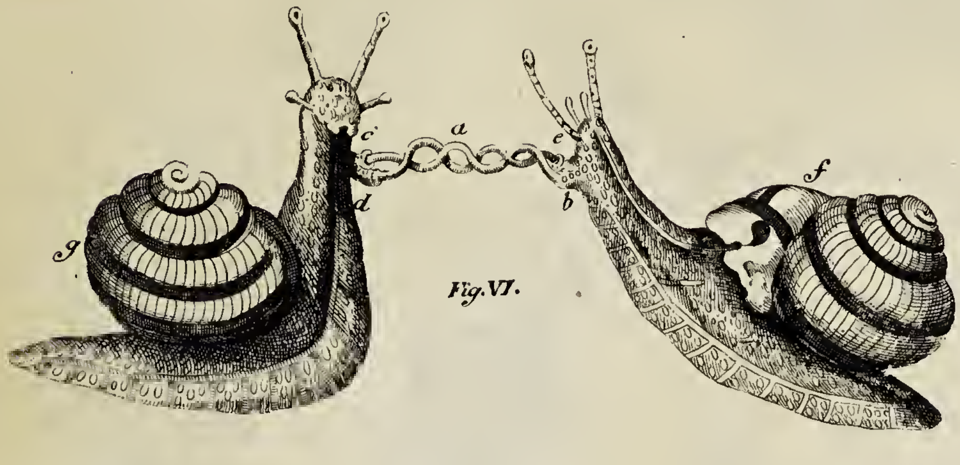

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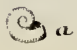
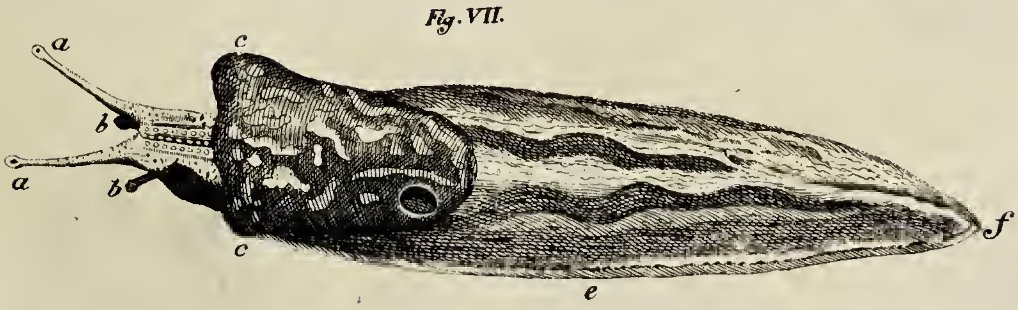


Fig. III.

Fig. VII.



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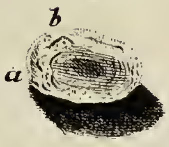

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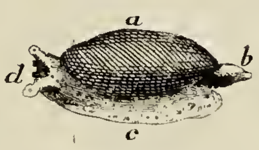

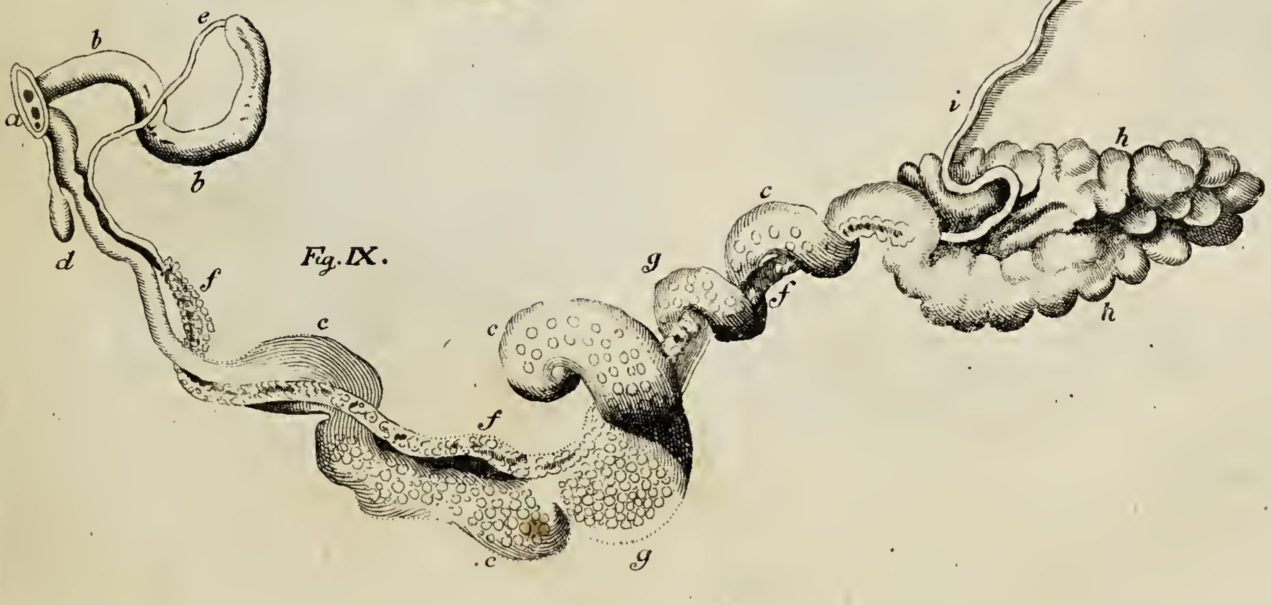

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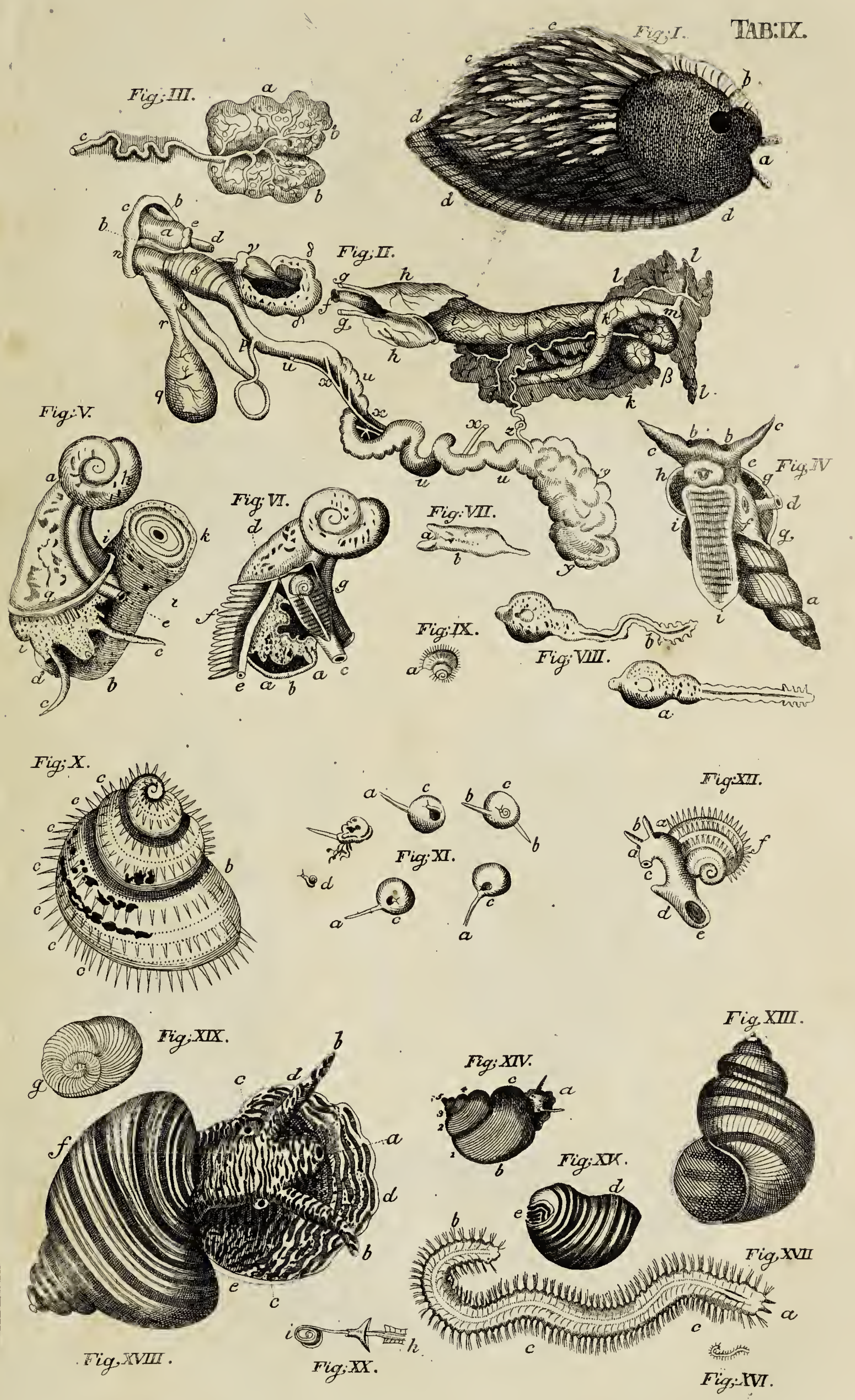
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Fig; XII.
Fig; XIII.
Fig; XIV.
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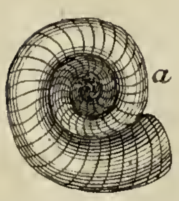
Fig; XVIII.
Fig; XIX.
Fig; XX.

TAB.X.

Fig; I.

Fig; IV.



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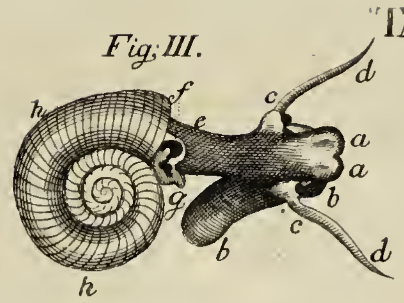

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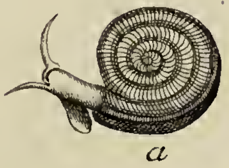

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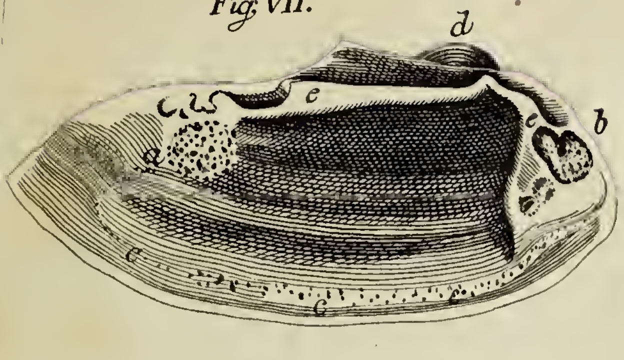

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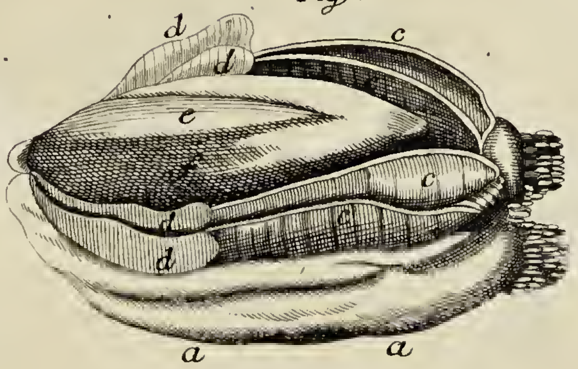

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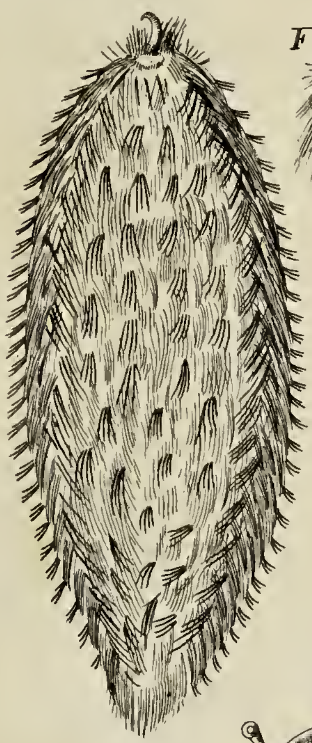

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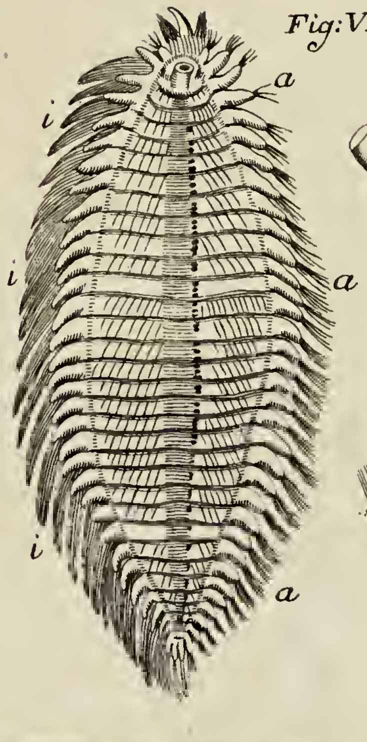
Fig; XI.

Fig; XII.

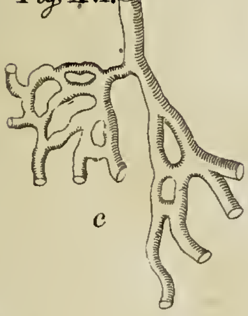
Fig; VIII.



Fig; IX

Fig; X.

Fig; XVI.



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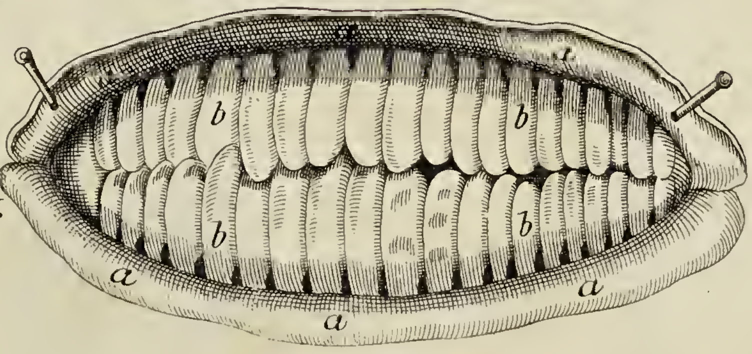

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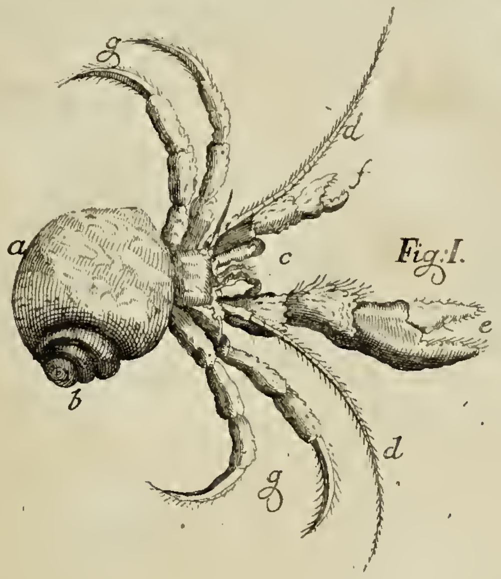
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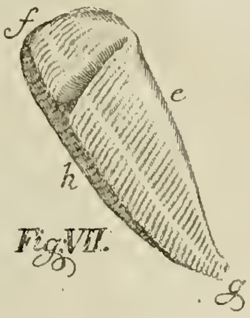
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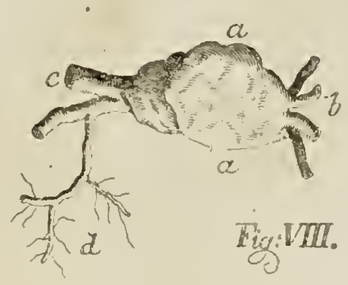
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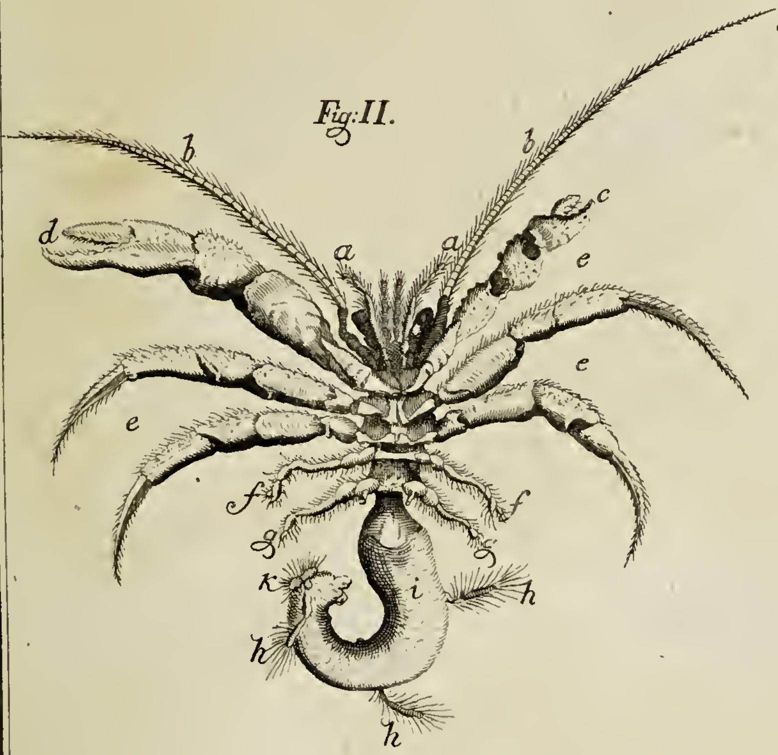
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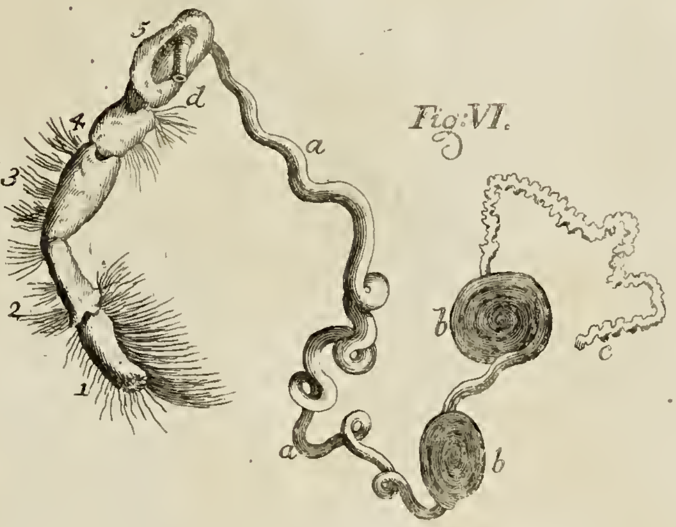
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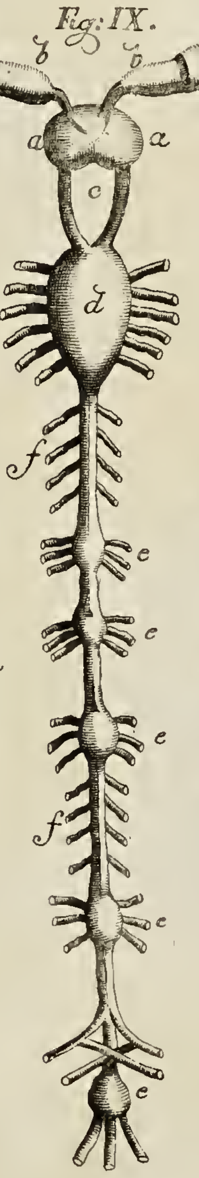
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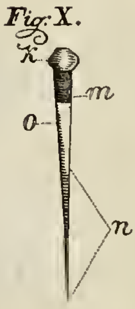
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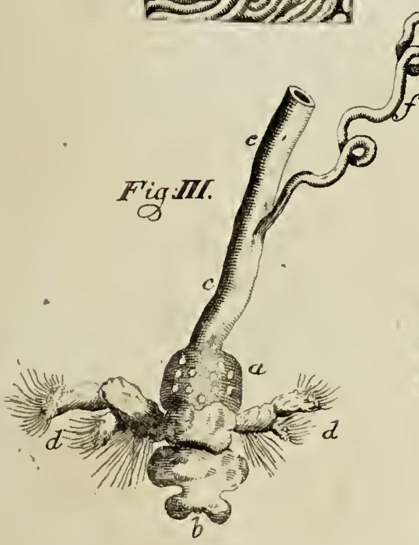
Fig: XI.

Fig: IV.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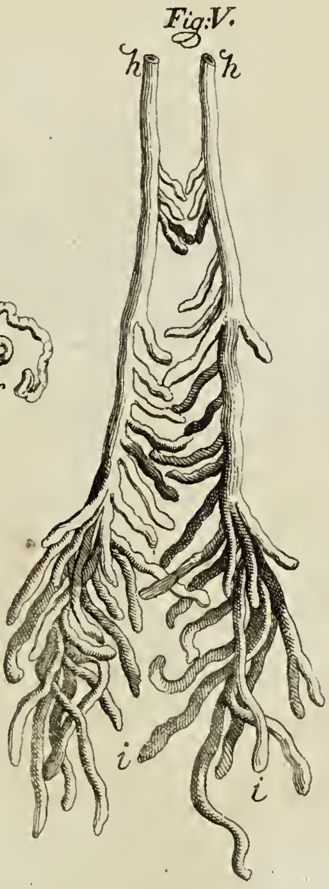
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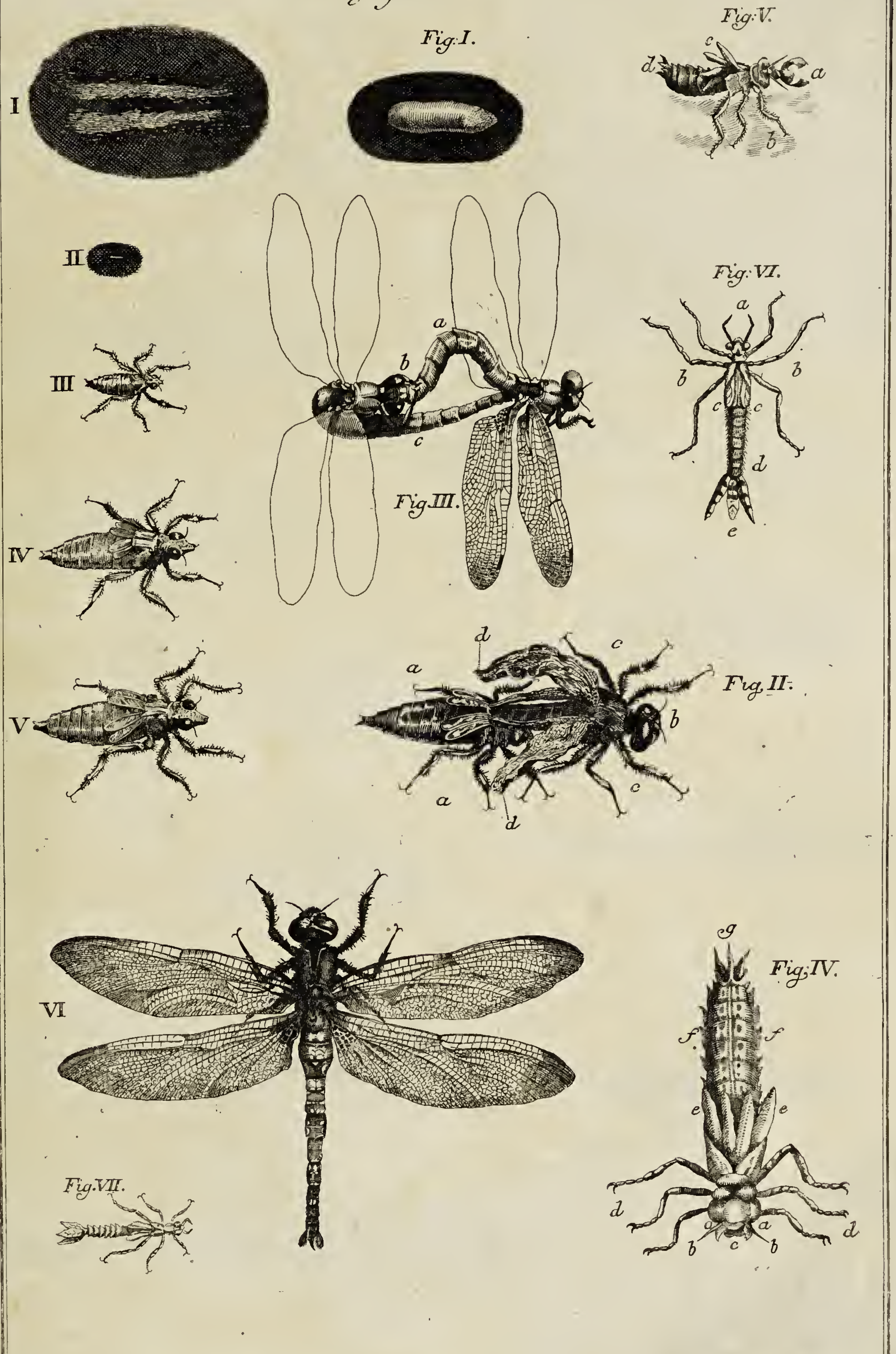
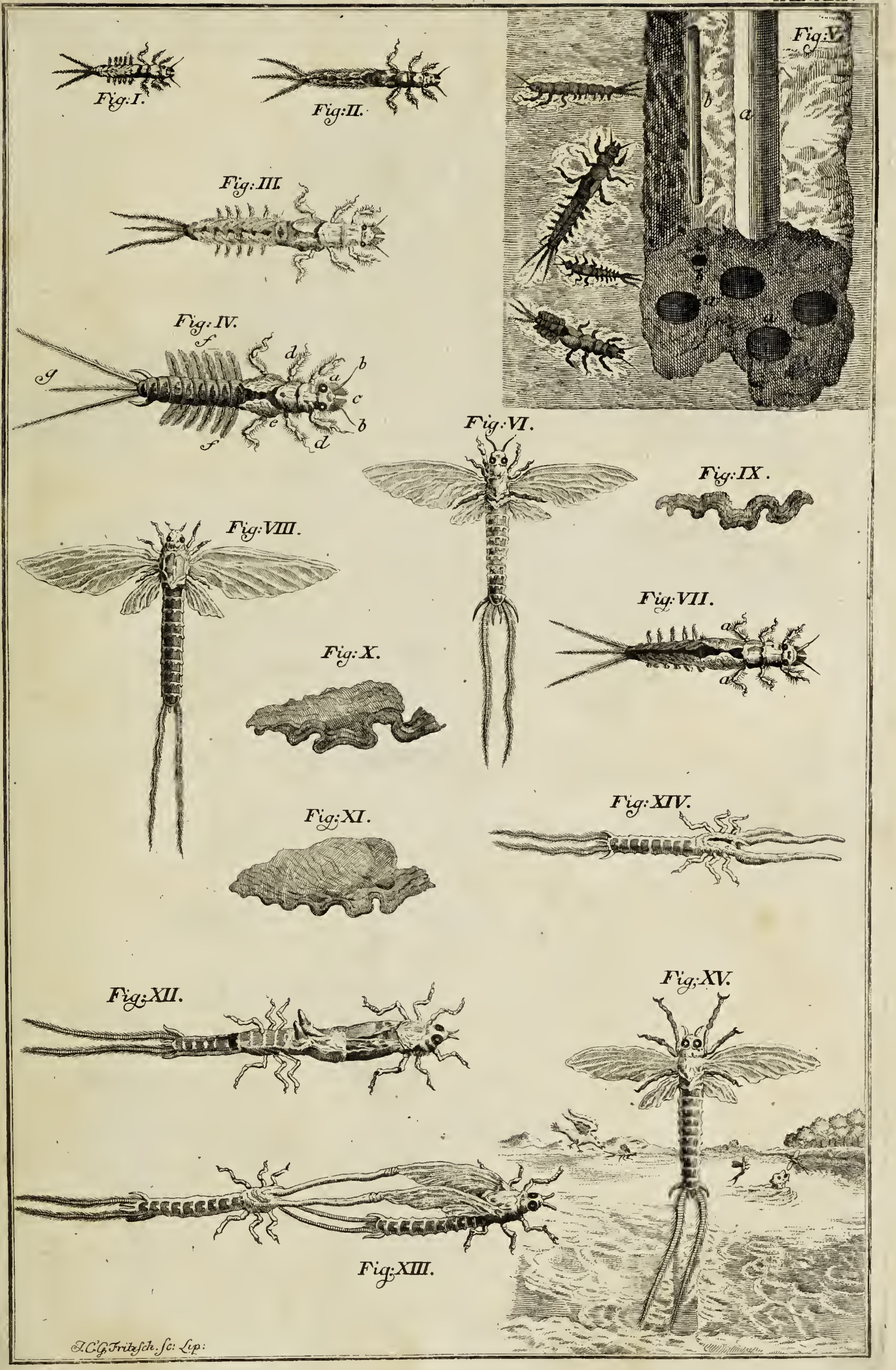
J. C. G. Fritzsch sc. Lipsiæ

Order the Second
Nymph = Vermicle

TAB: XII.



J. C. G. Fritzsch sc.



J.C.G.Fritzsch. sc: Lip:

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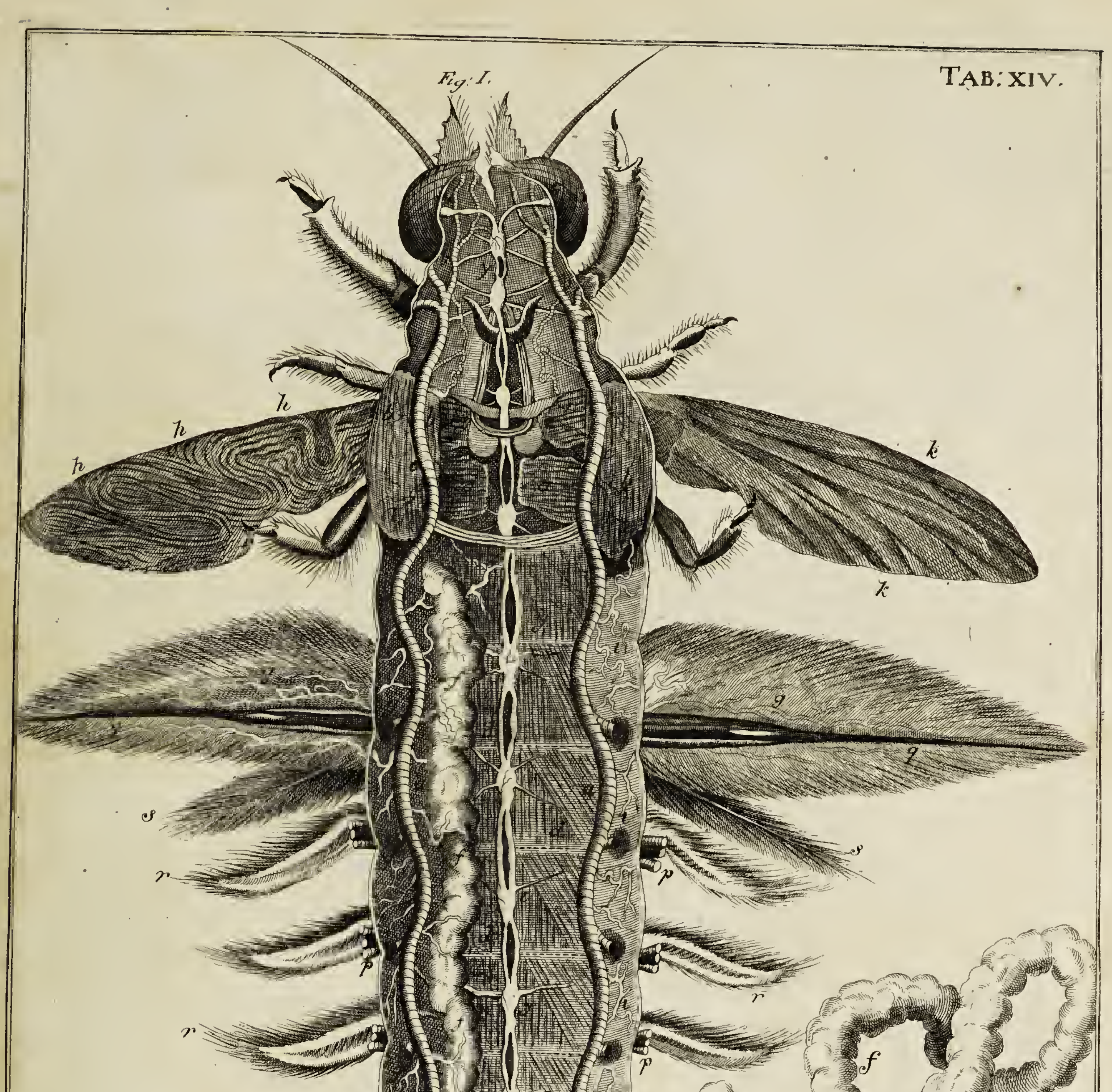

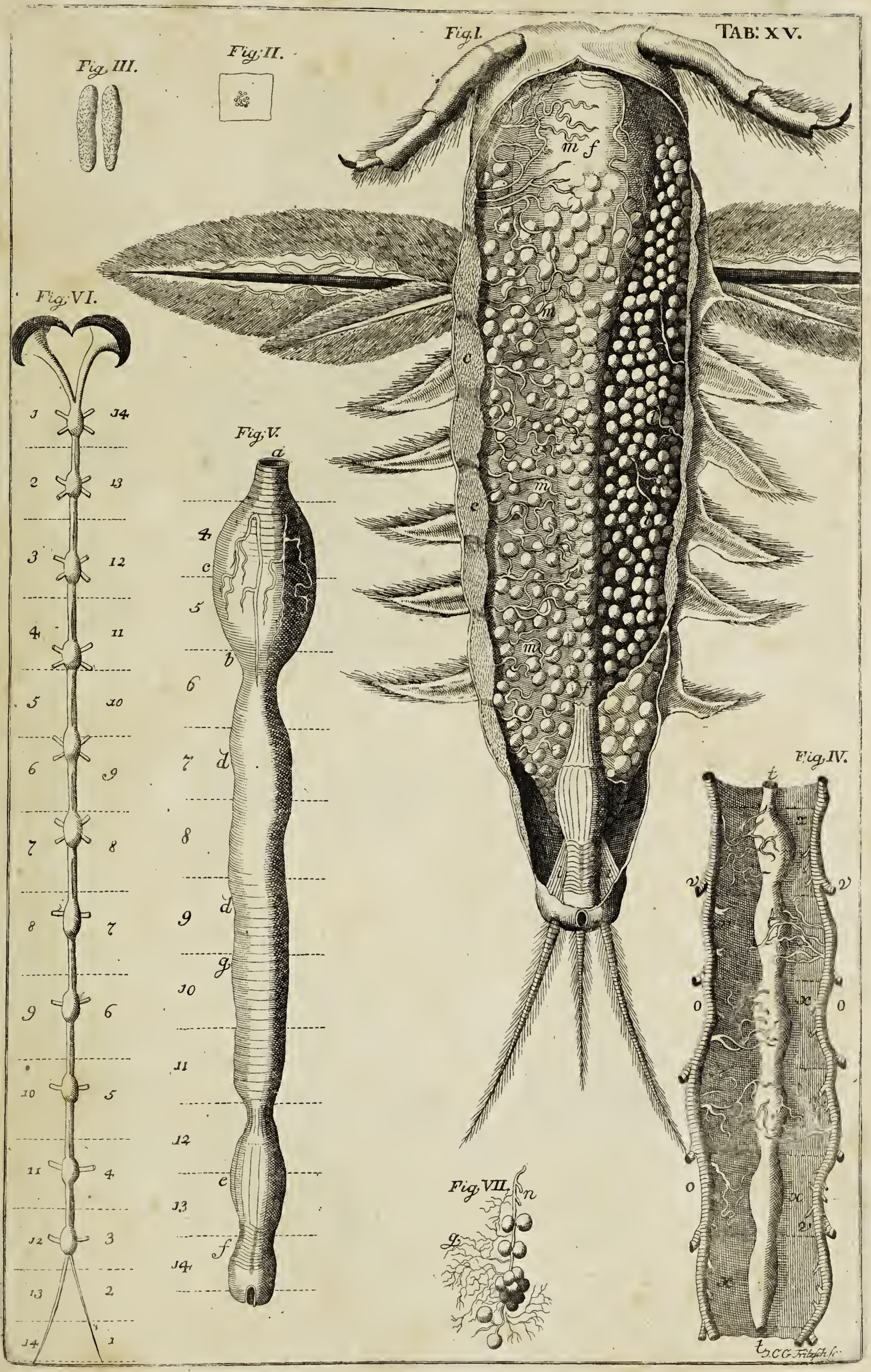
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Fig. VI.
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Fig. VII.
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J. C. G. Fritzsch sc.

Order the Third
Nymph

TAB·XVI.

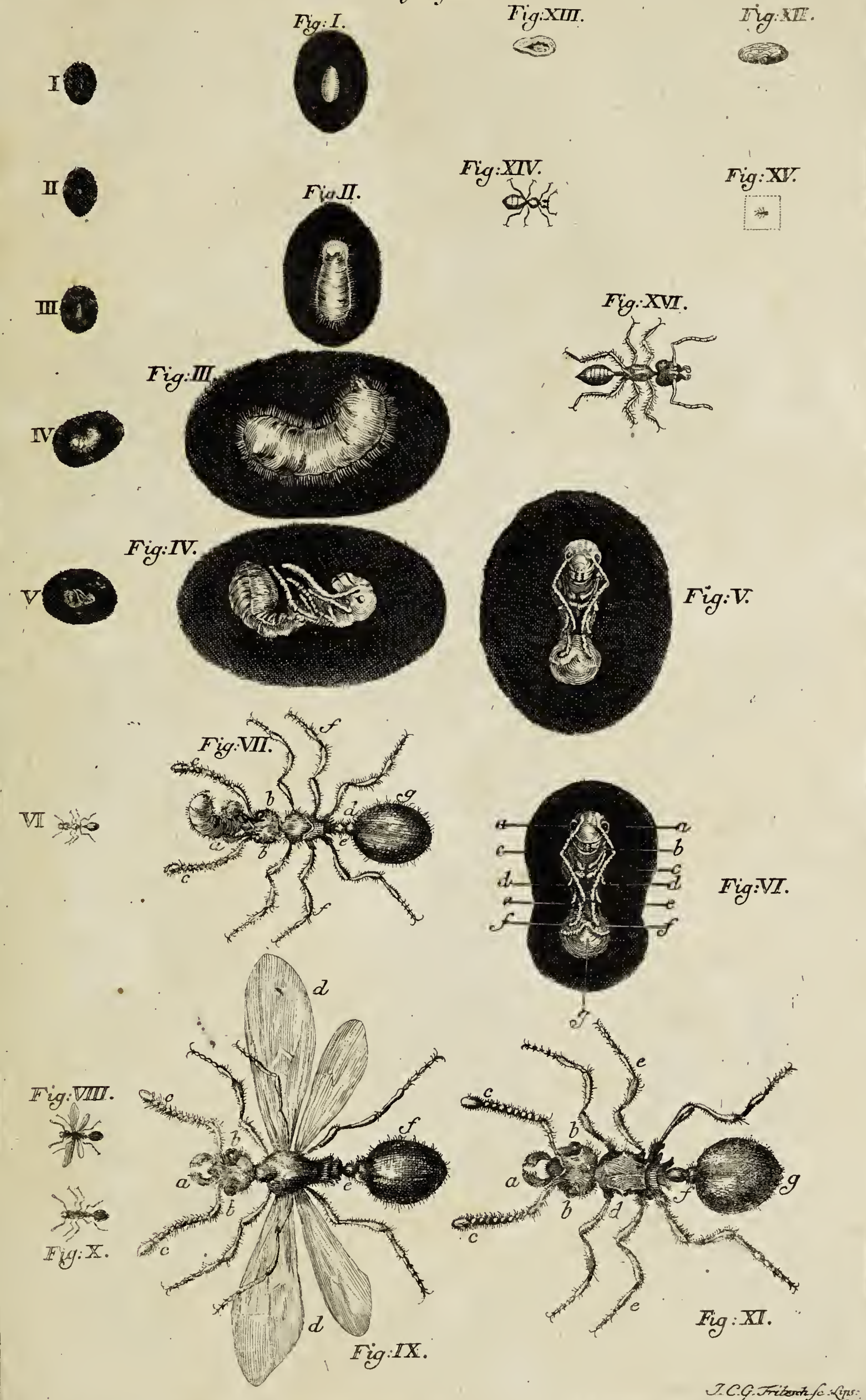
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Fig: V.
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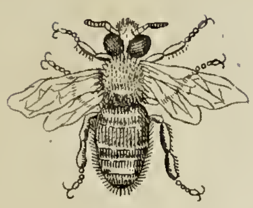
Fig: X.
Fig: IX.
Fig: XI.

J.C.G. Fritzsch sc. Lips.

Fig: IV.



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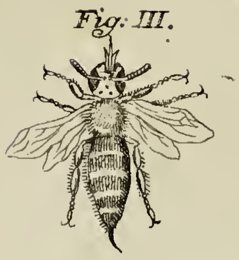

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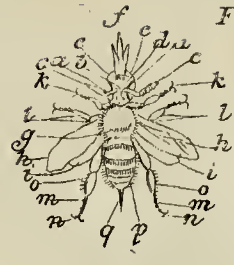

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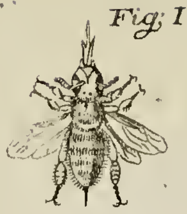

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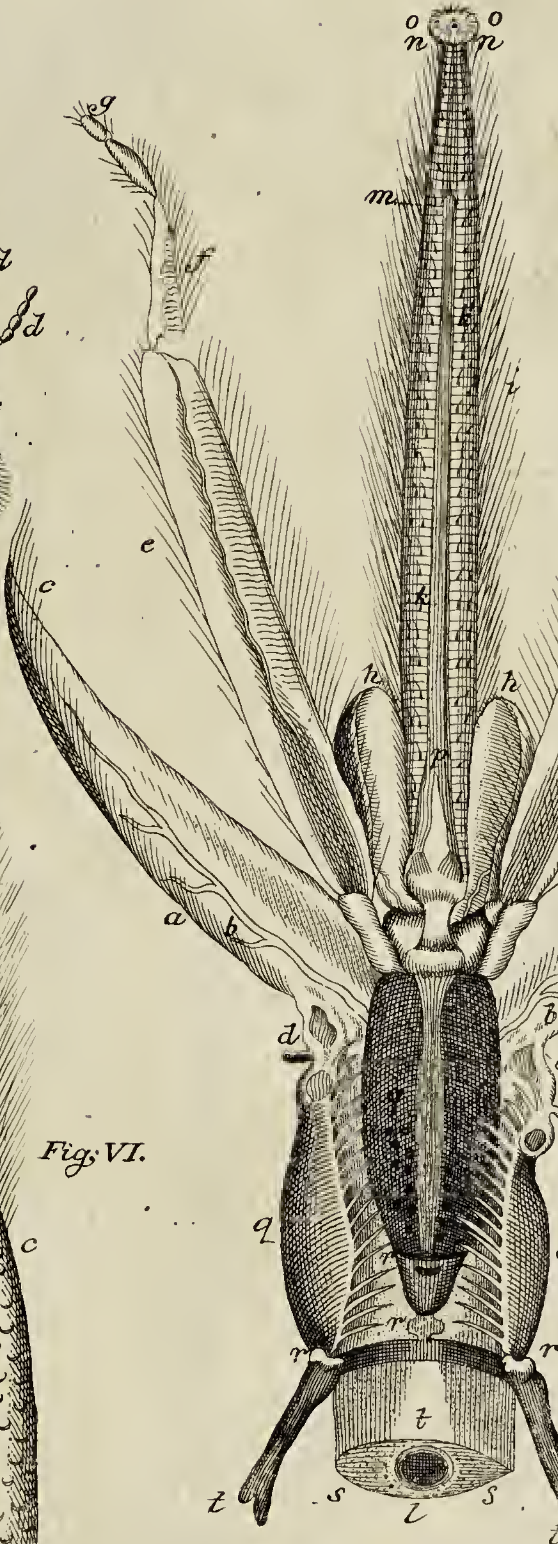

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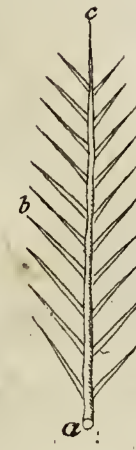

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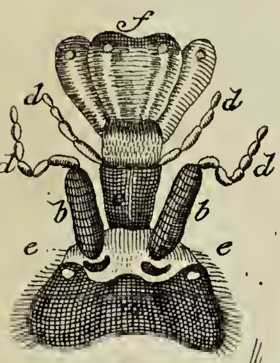

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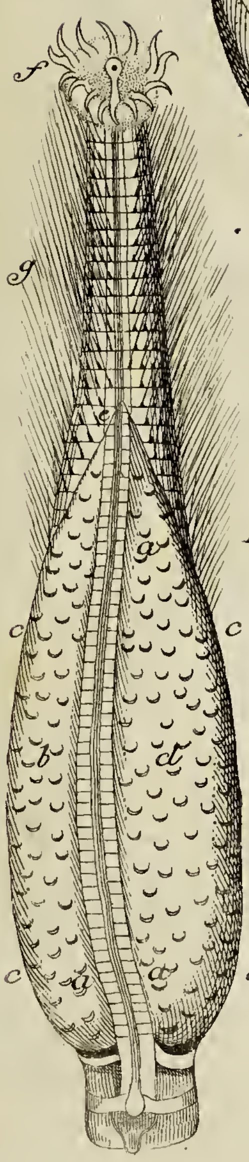

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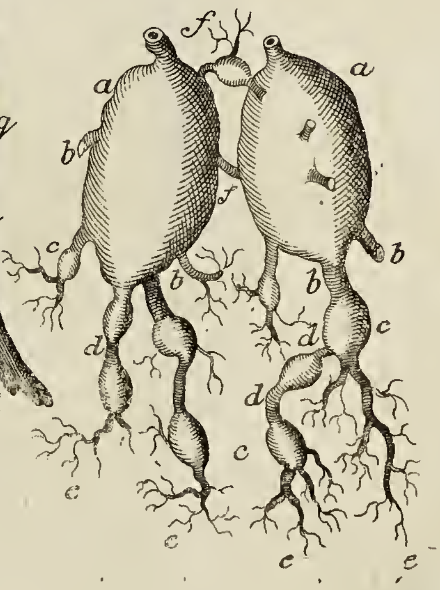

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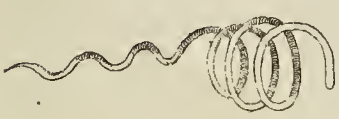

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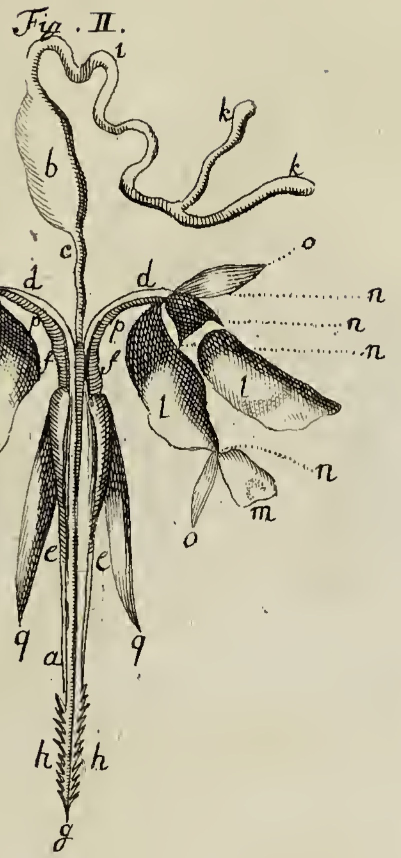

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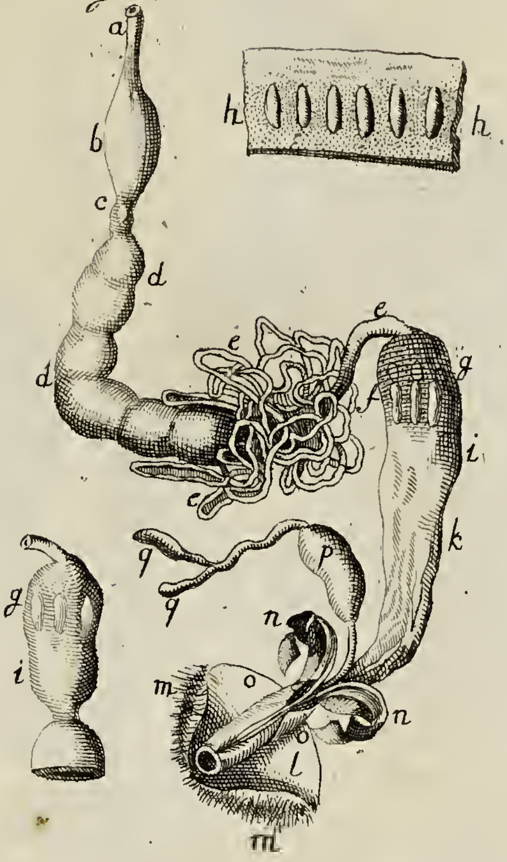

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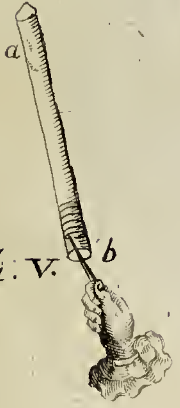

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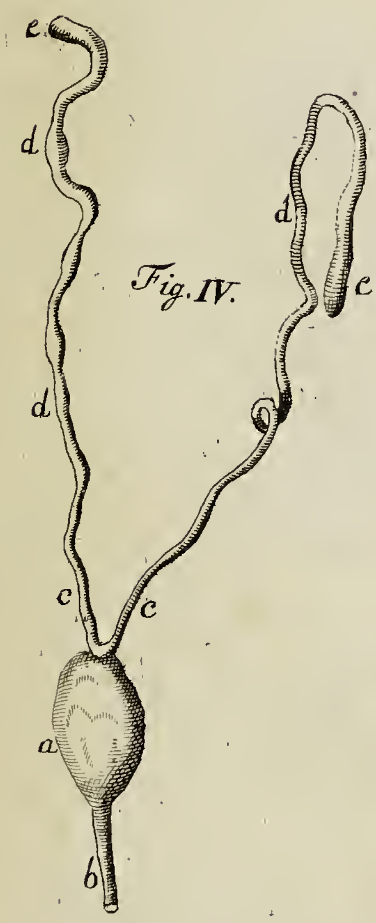

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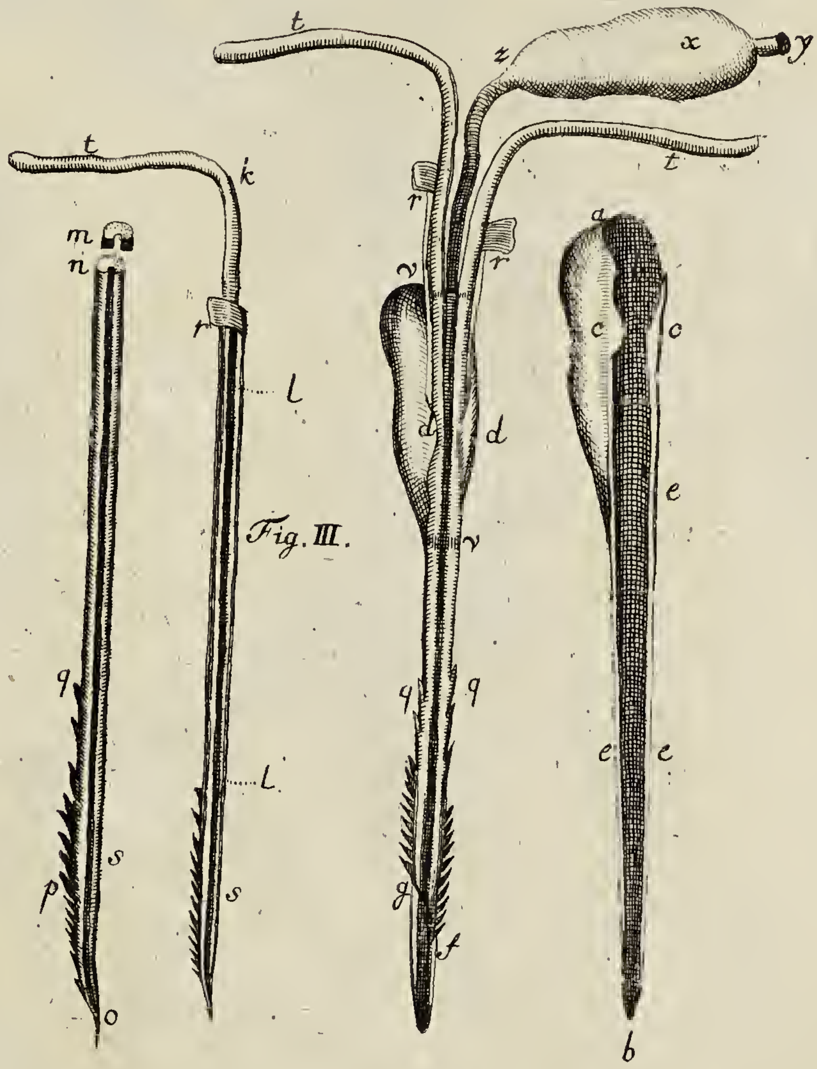

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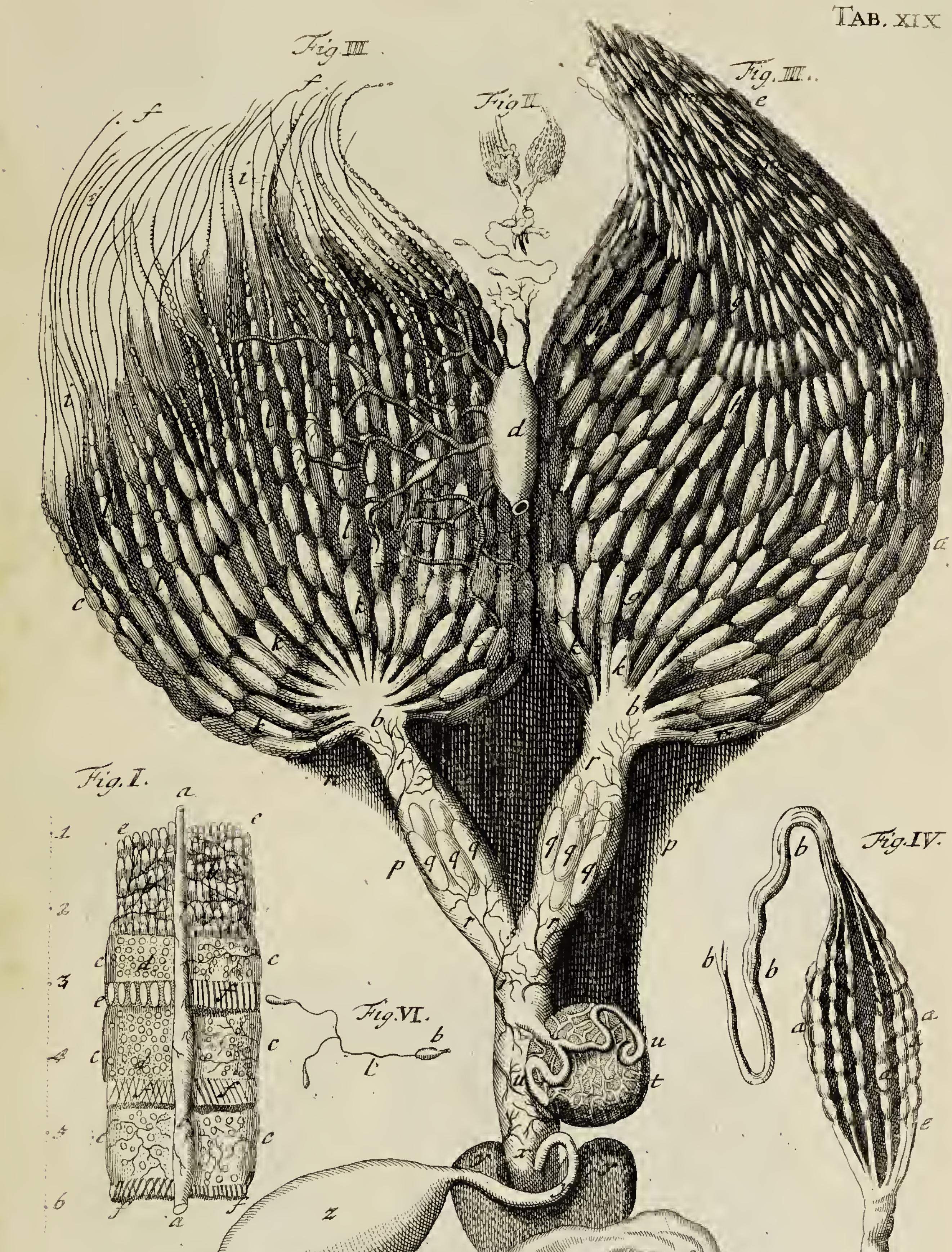
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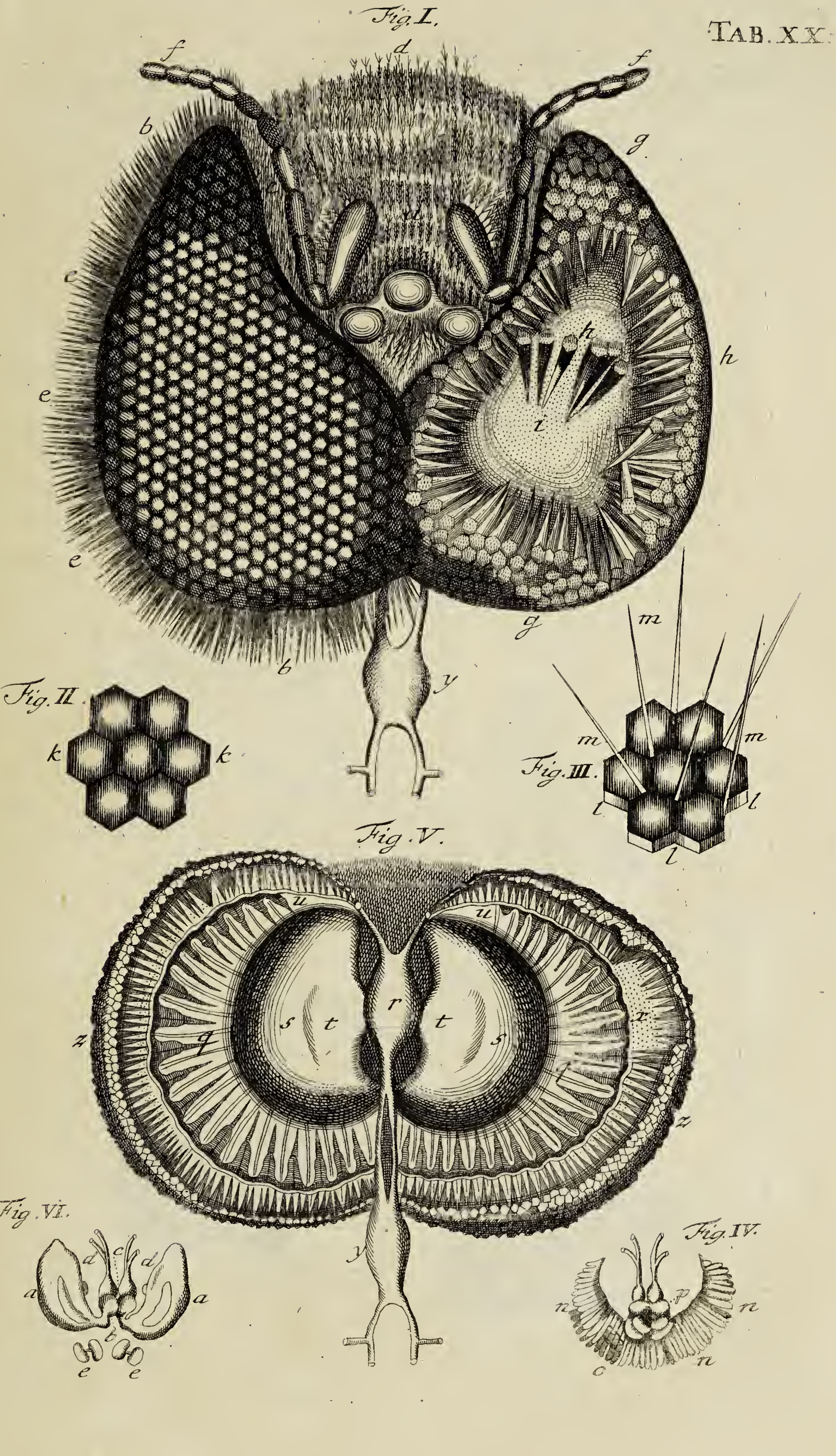
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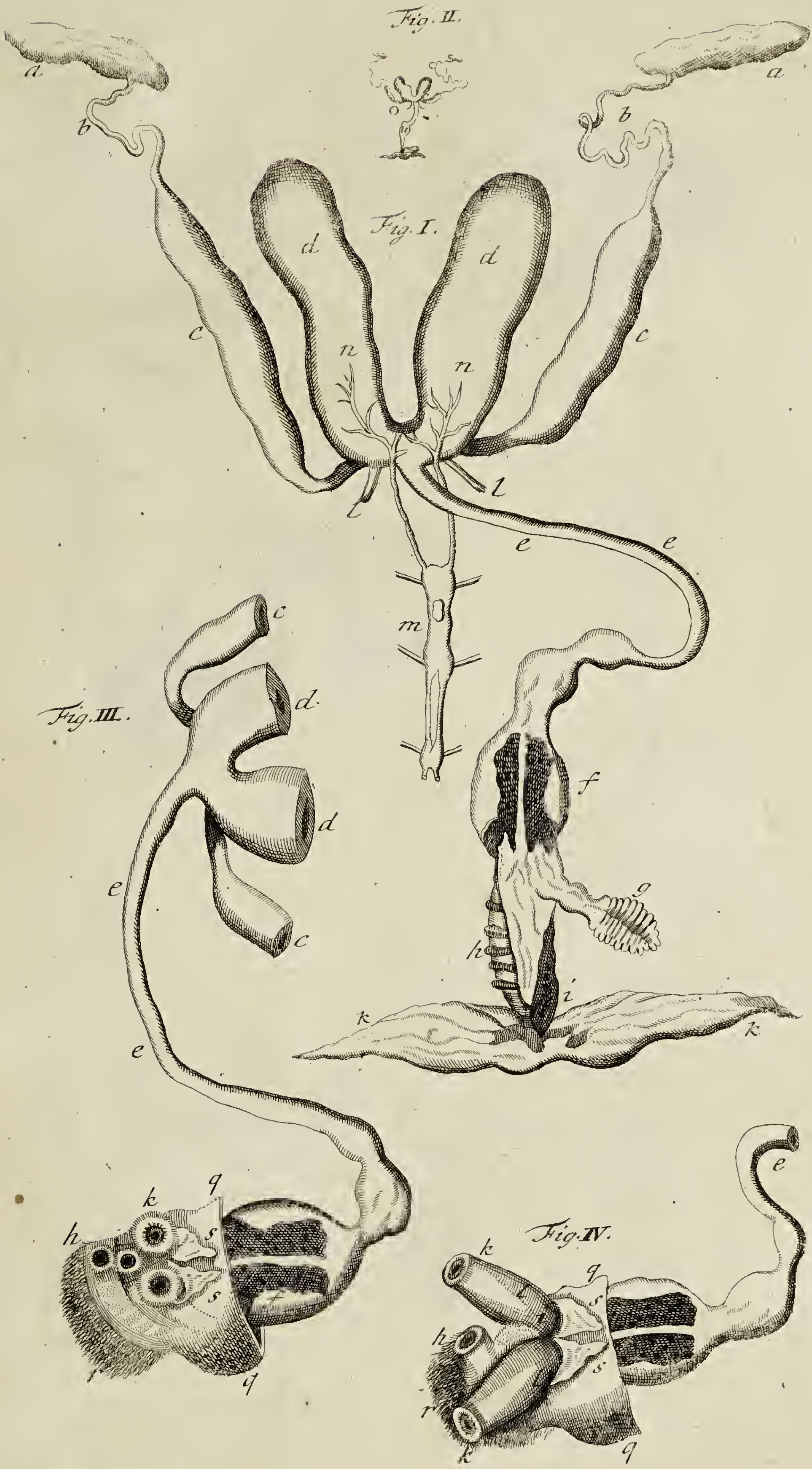
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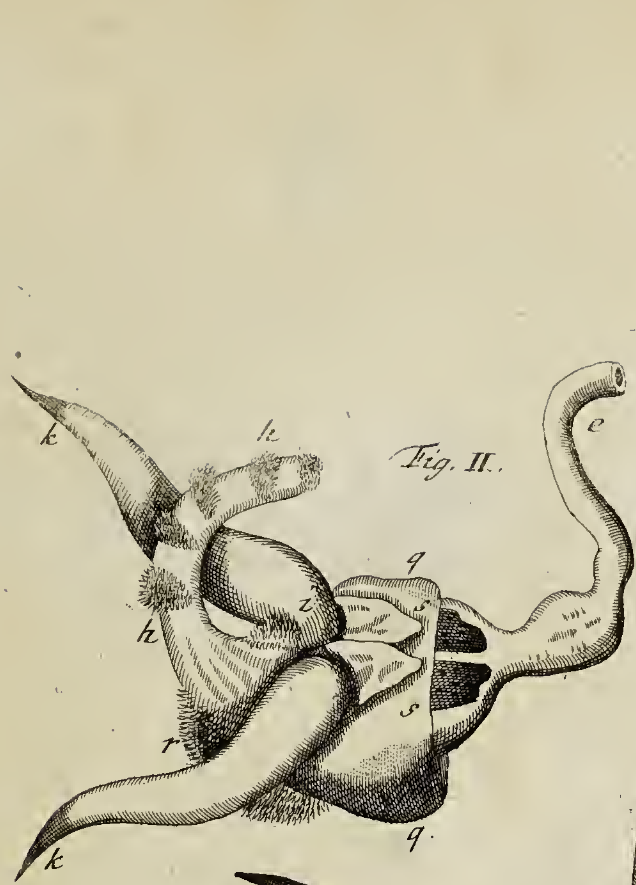
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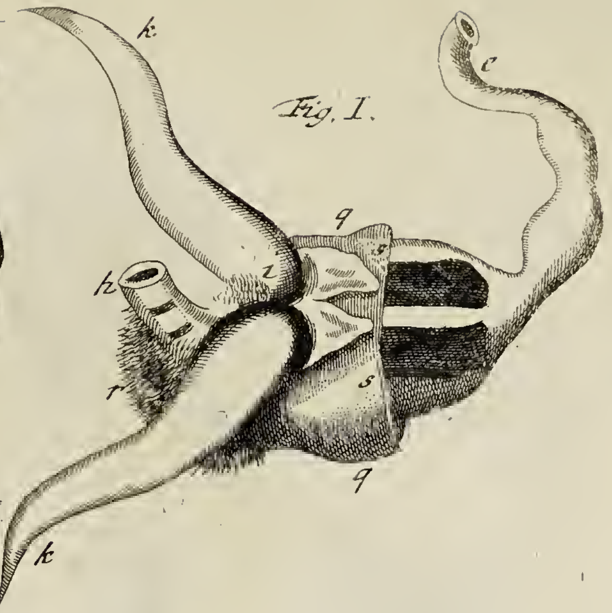
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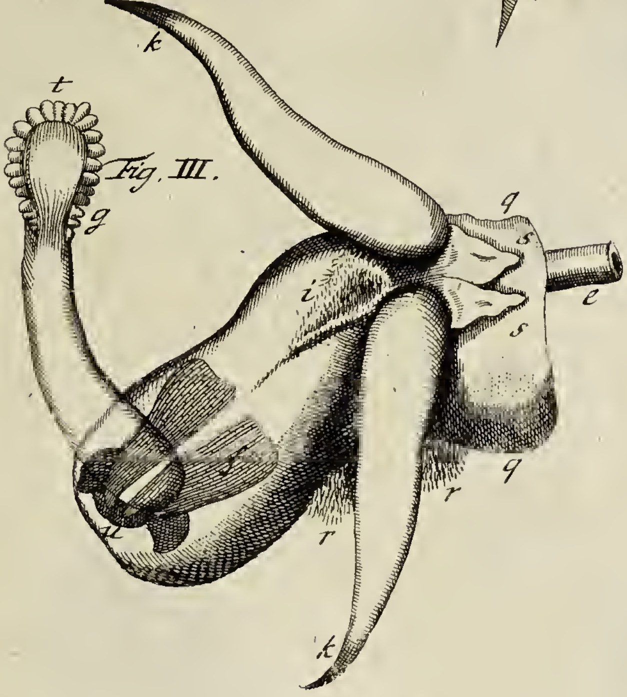
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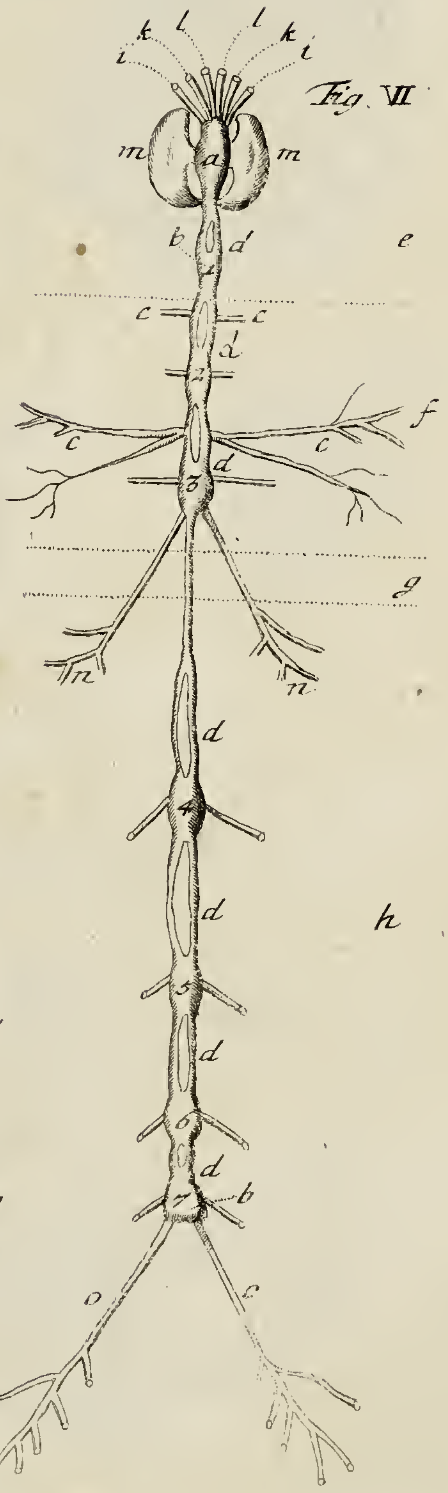
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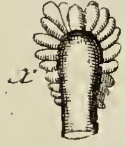
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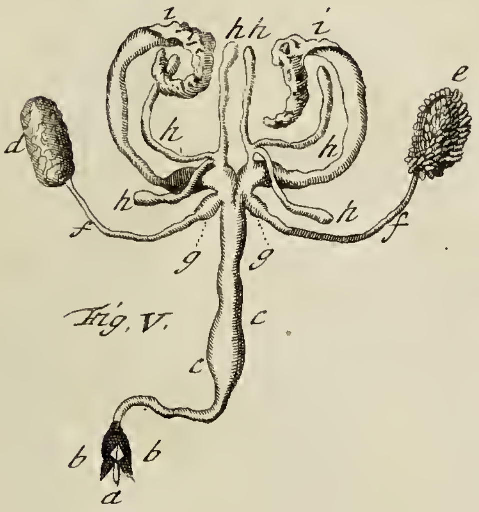
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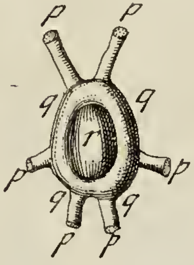
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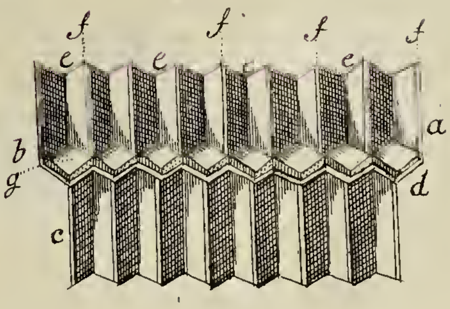

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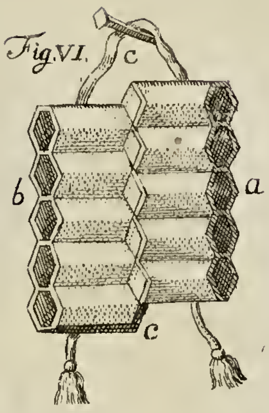

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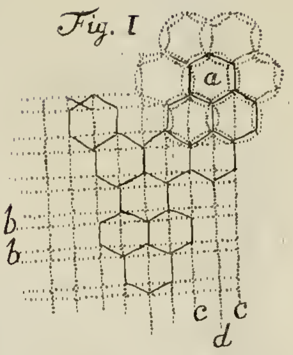

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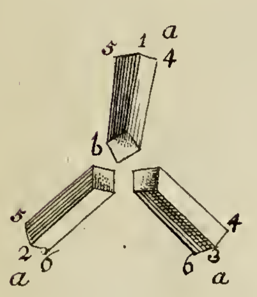

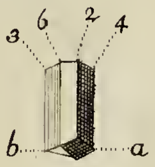

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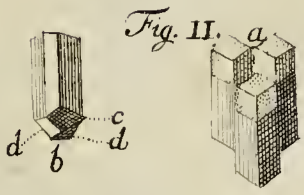

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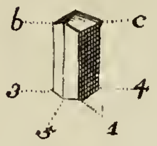

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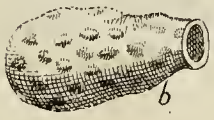

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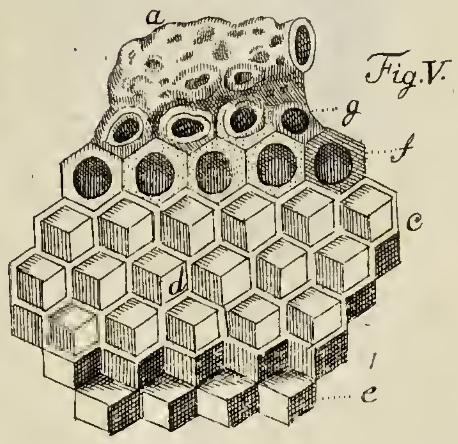

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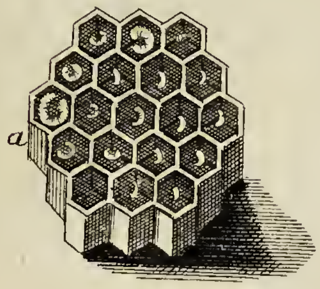

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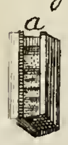

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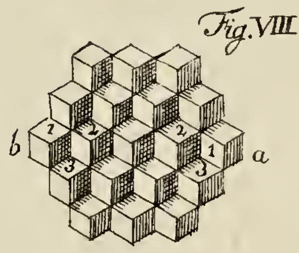

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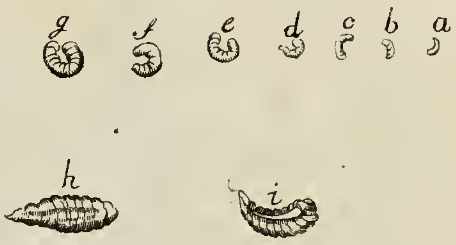

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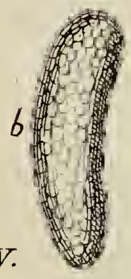

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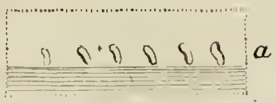

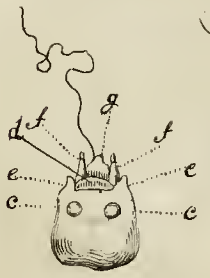

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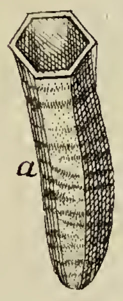

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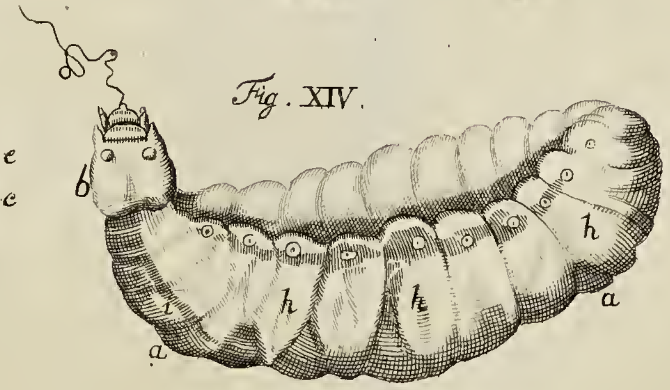

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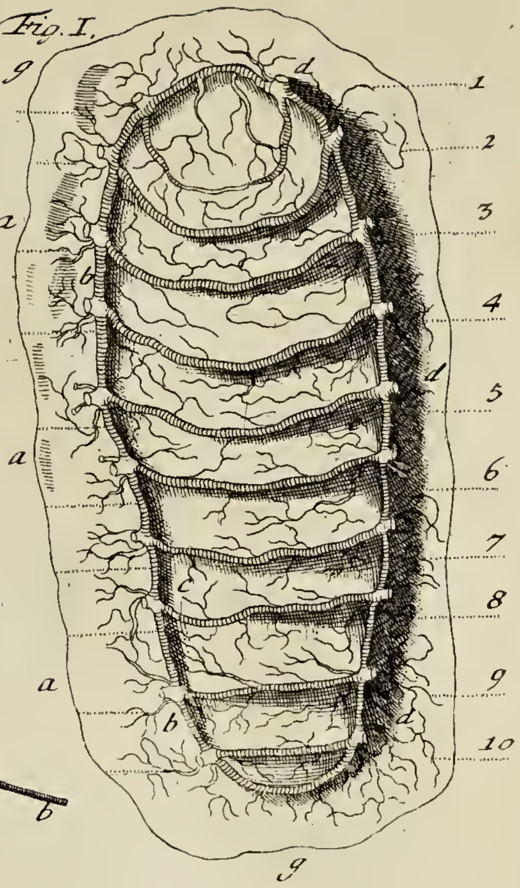

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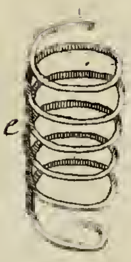

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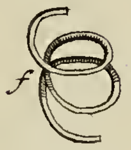

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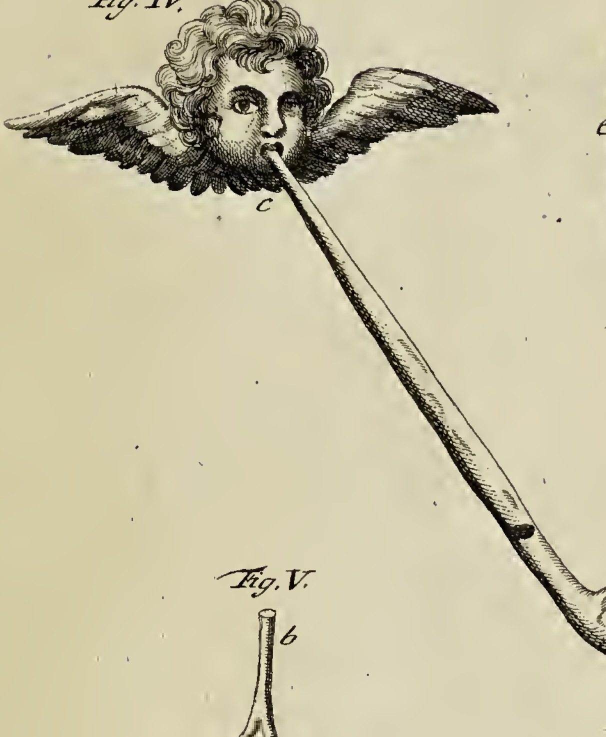

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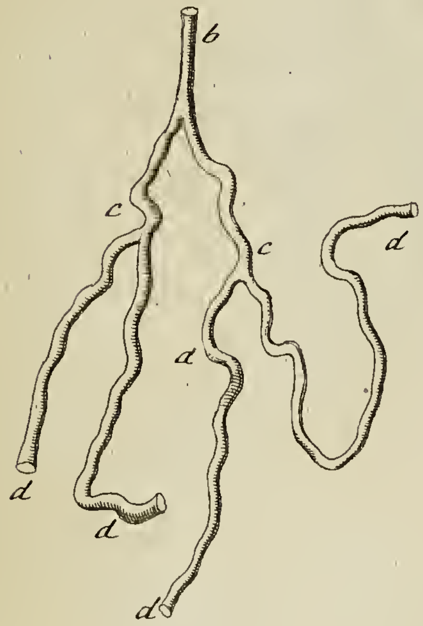

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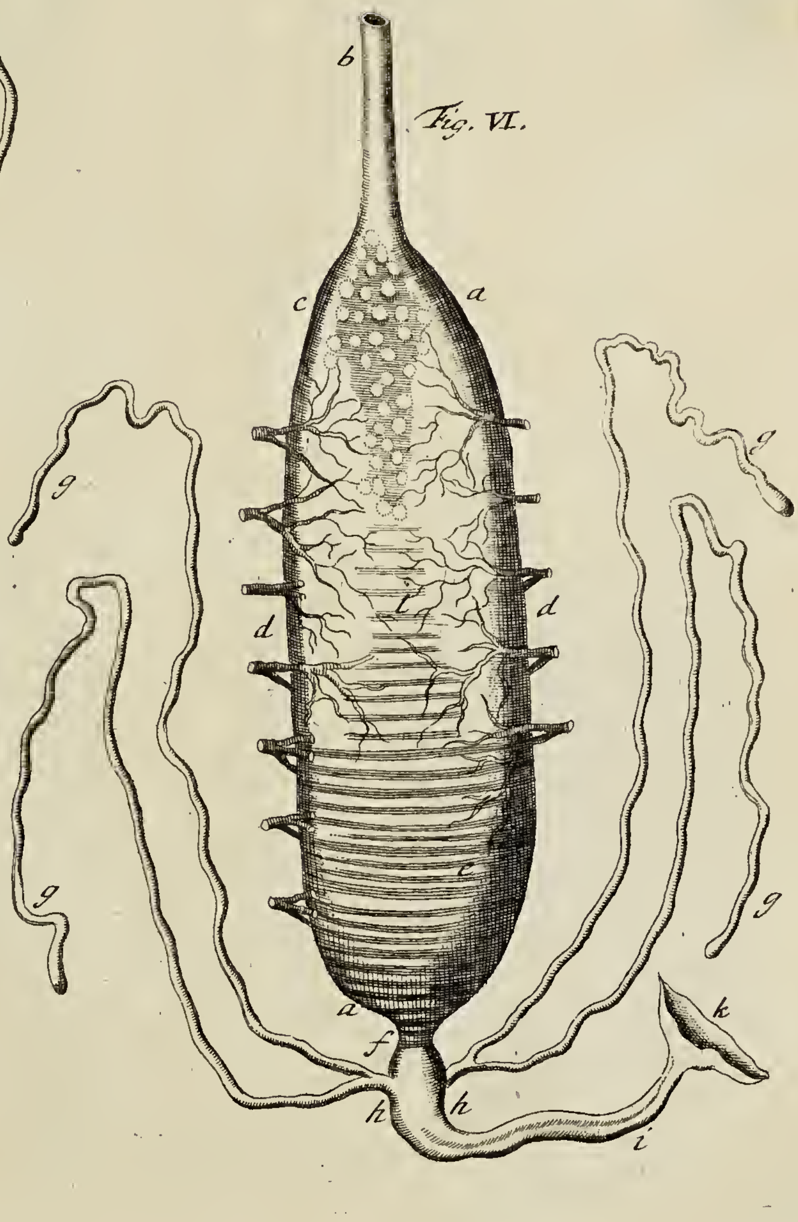

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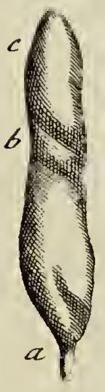

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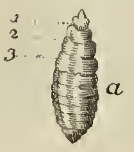

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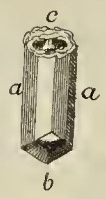

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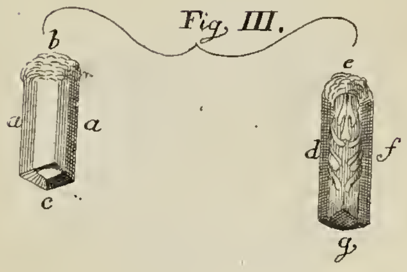

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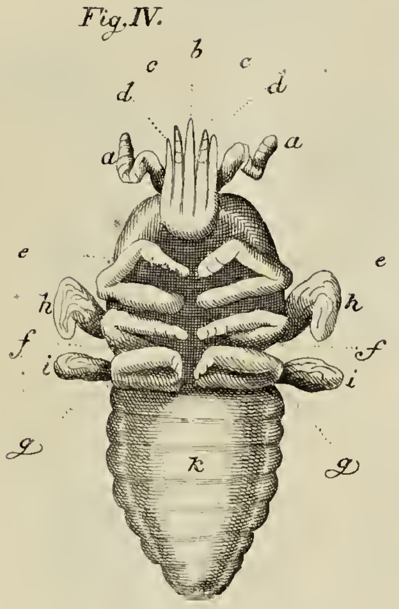

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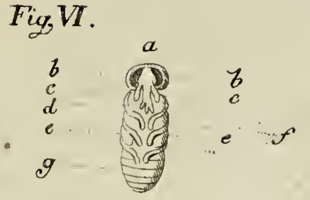

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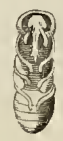

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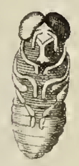

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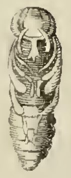

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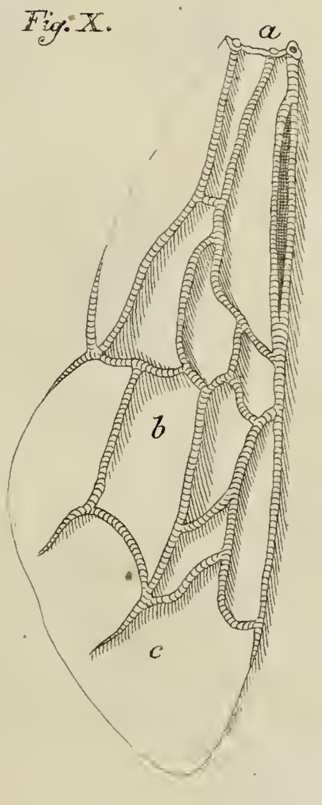

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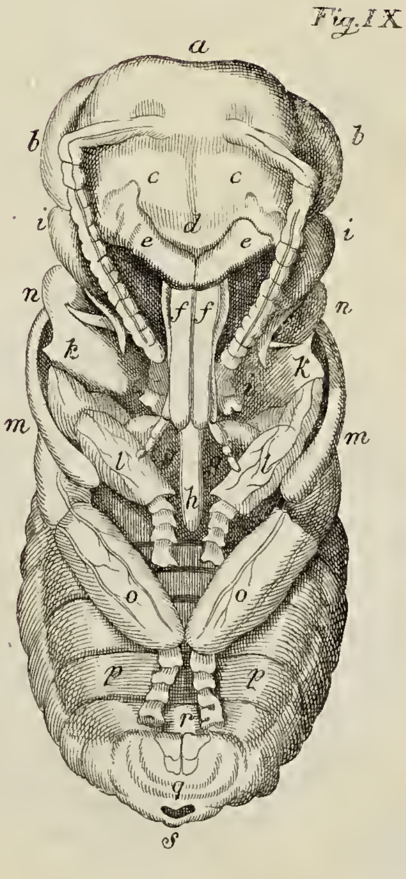

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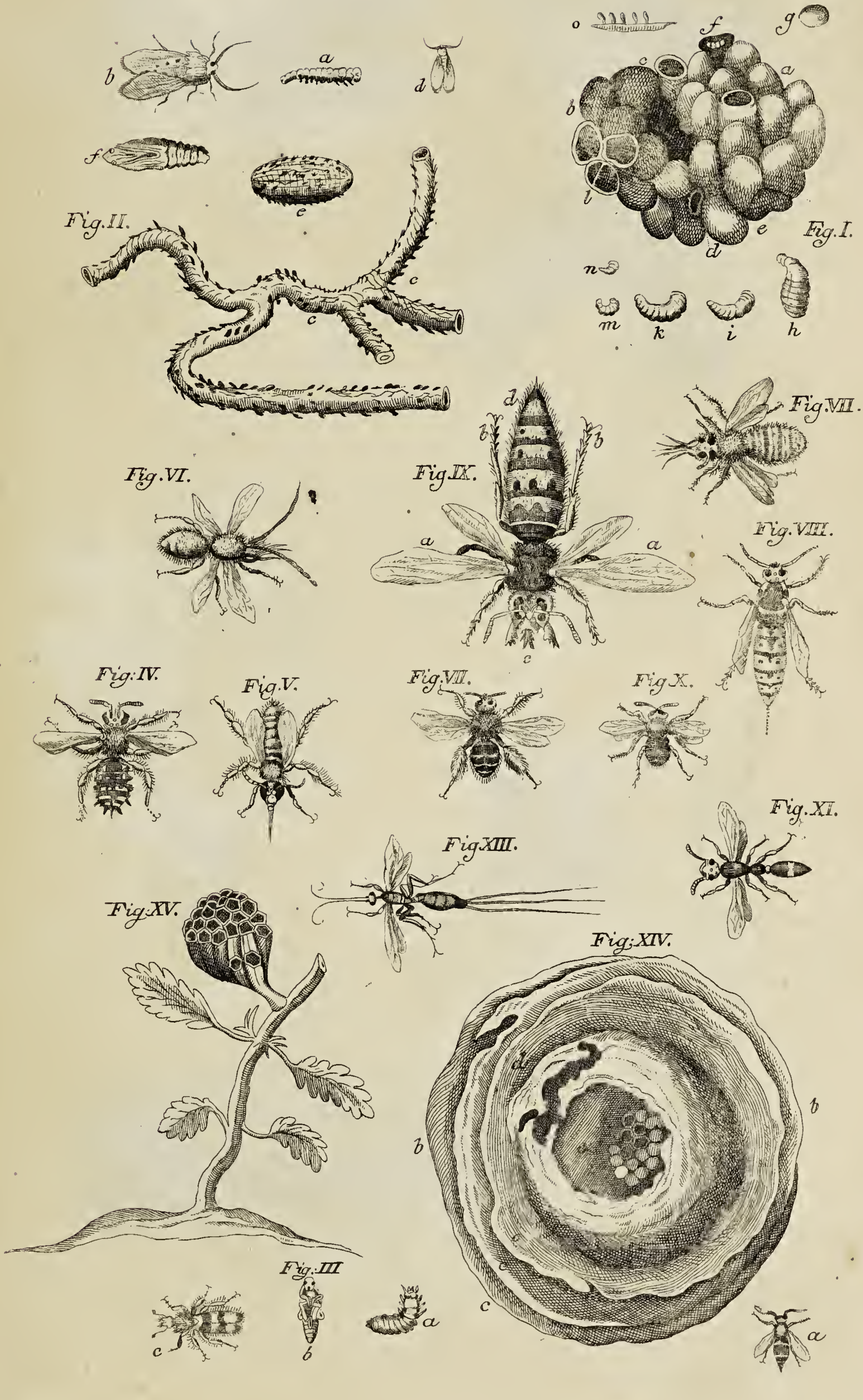
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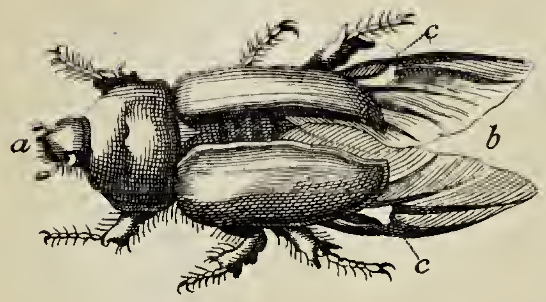

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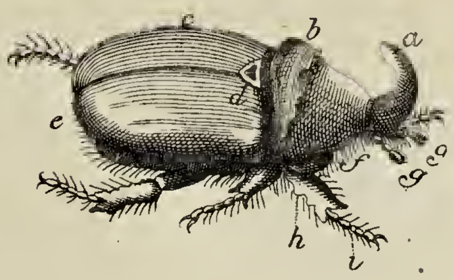

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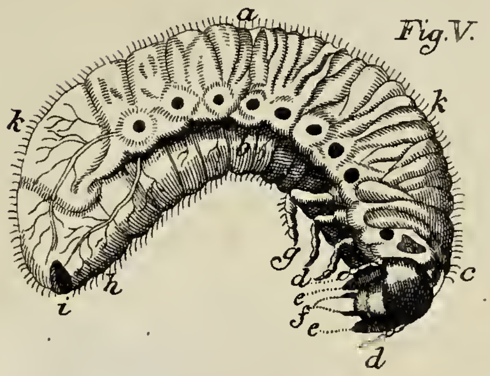

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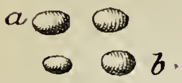

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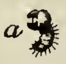

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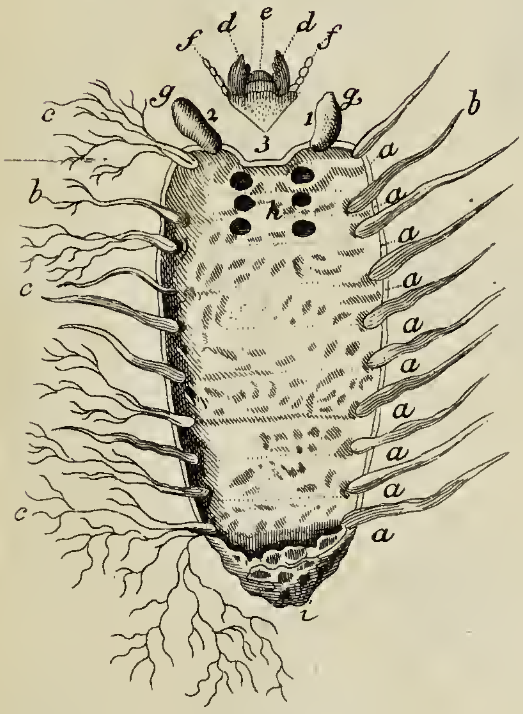

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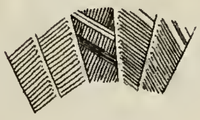


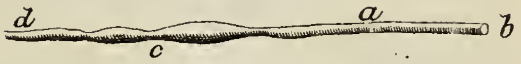
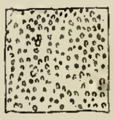


Fig. VIII.

Fig. IX.



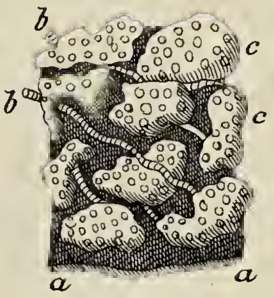
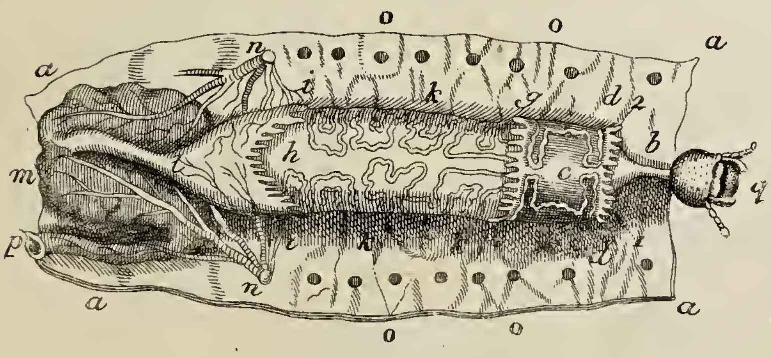


Fig X.

Fig: XI.



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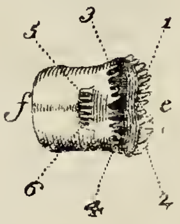

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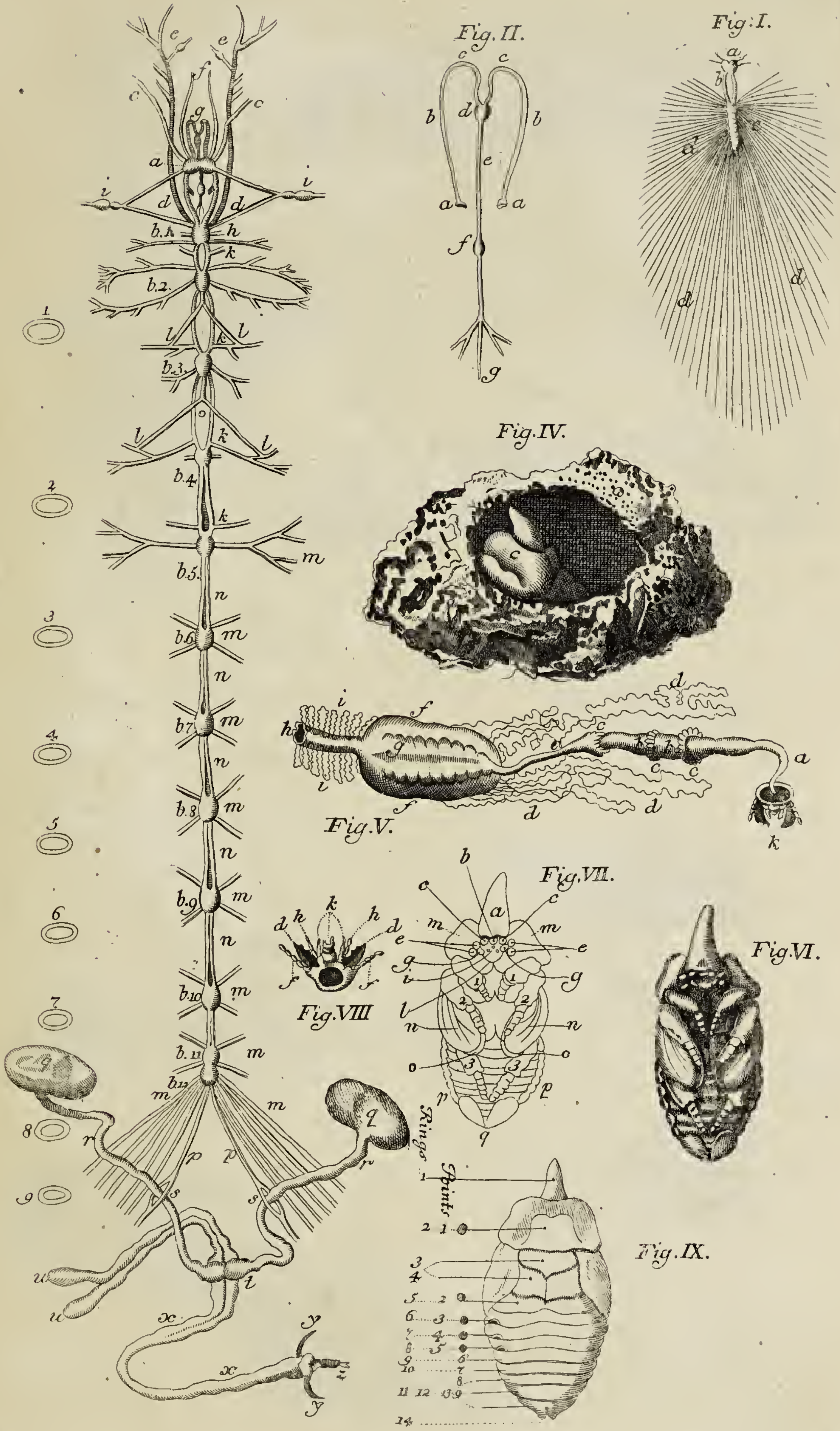
Fig. III.
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Fig. IV.
Fig. V.
Fig. VI.
Fig. VII.
Fig. VIII
Fig. IX.
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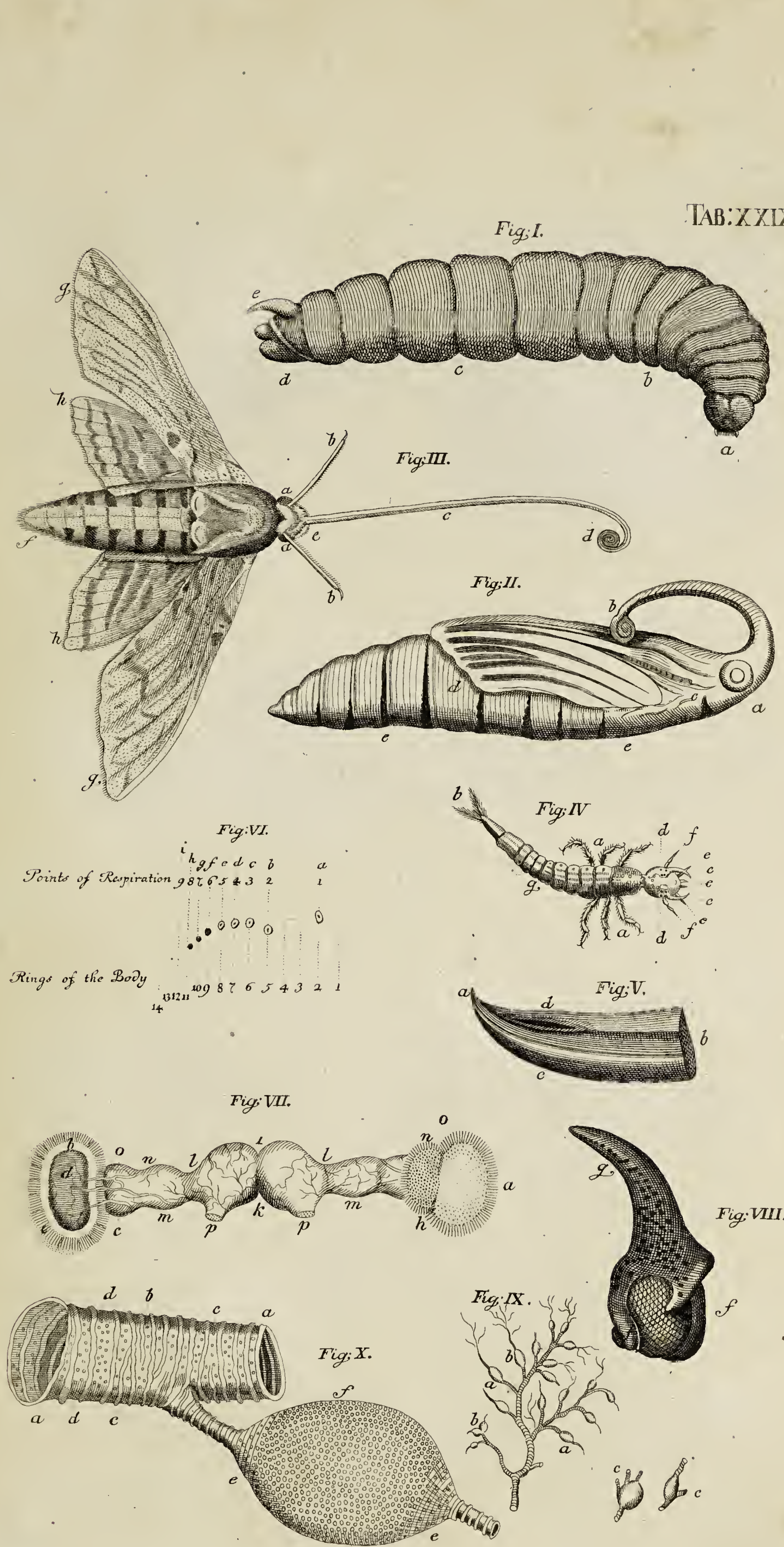

J. C. G. Fritzsch. sc.

TAB: XXX.

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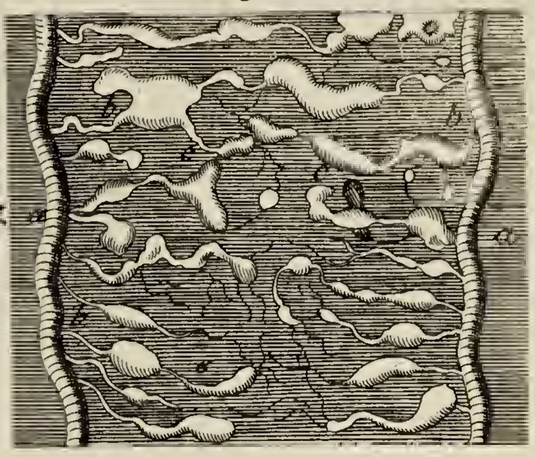

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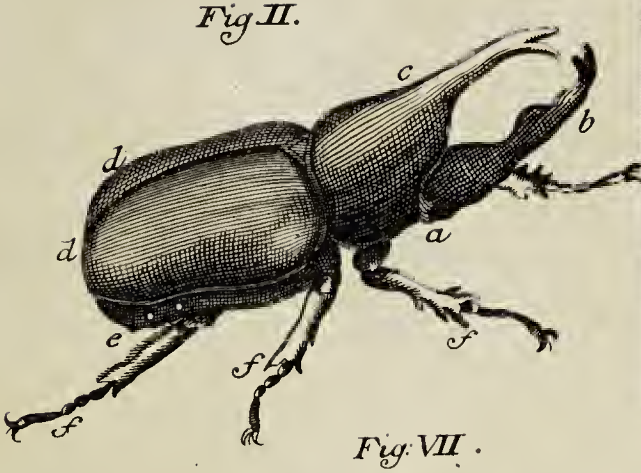

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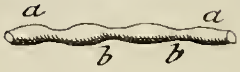

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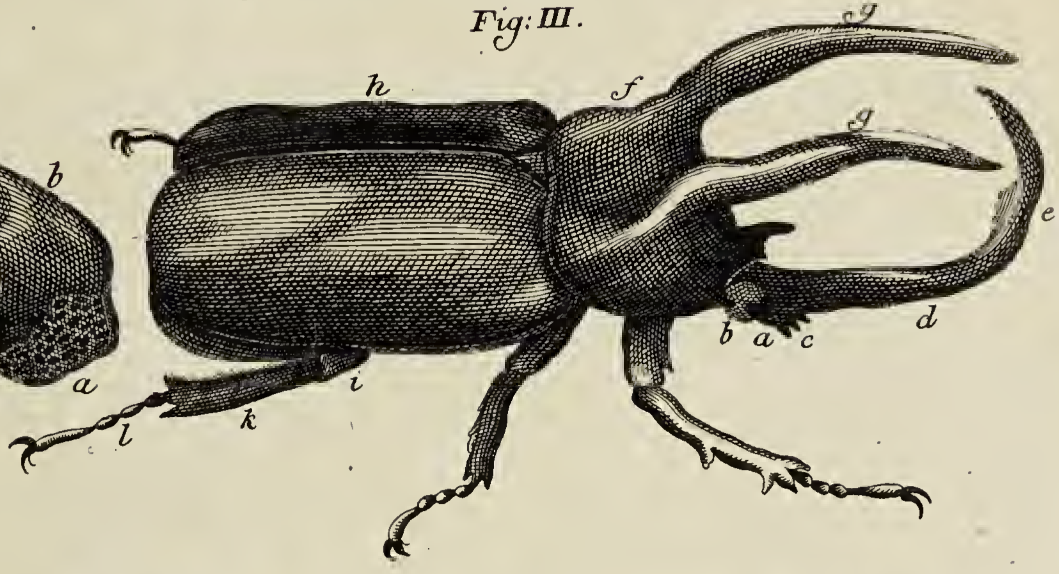

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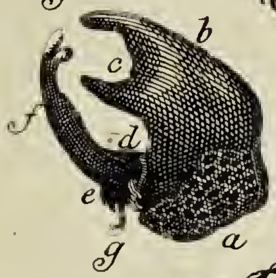

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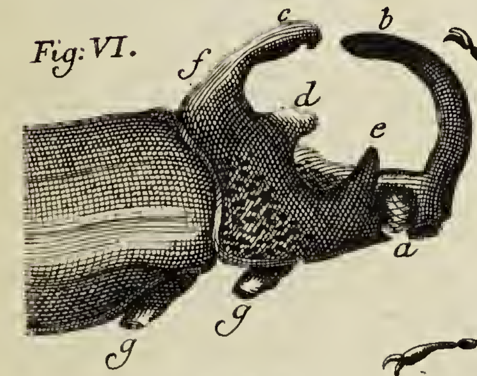

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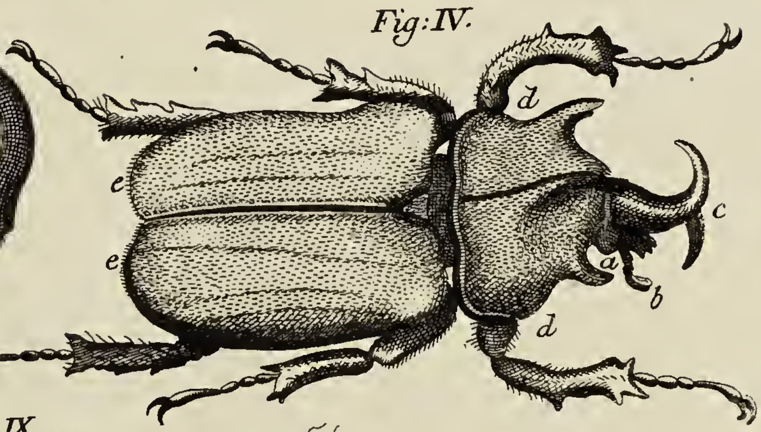

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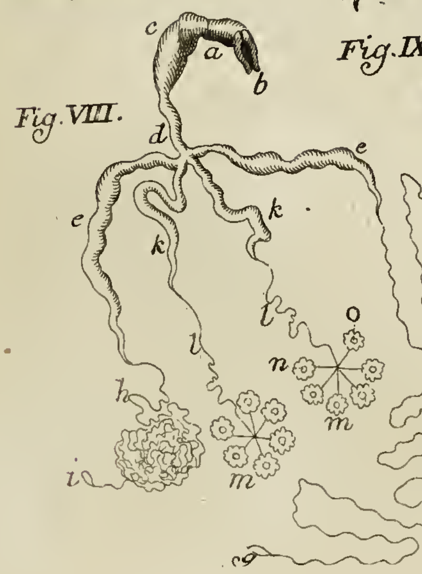

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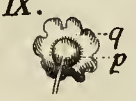

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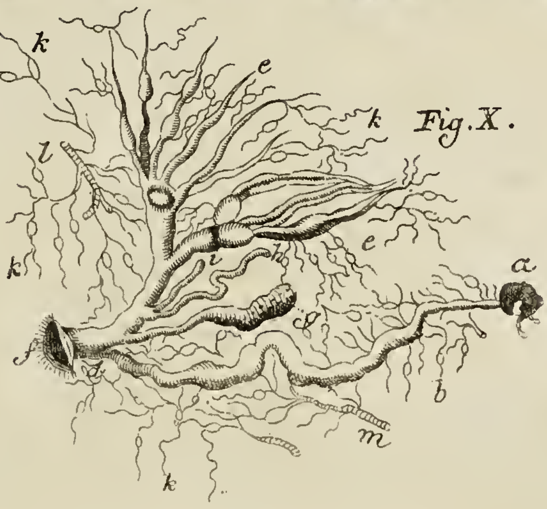

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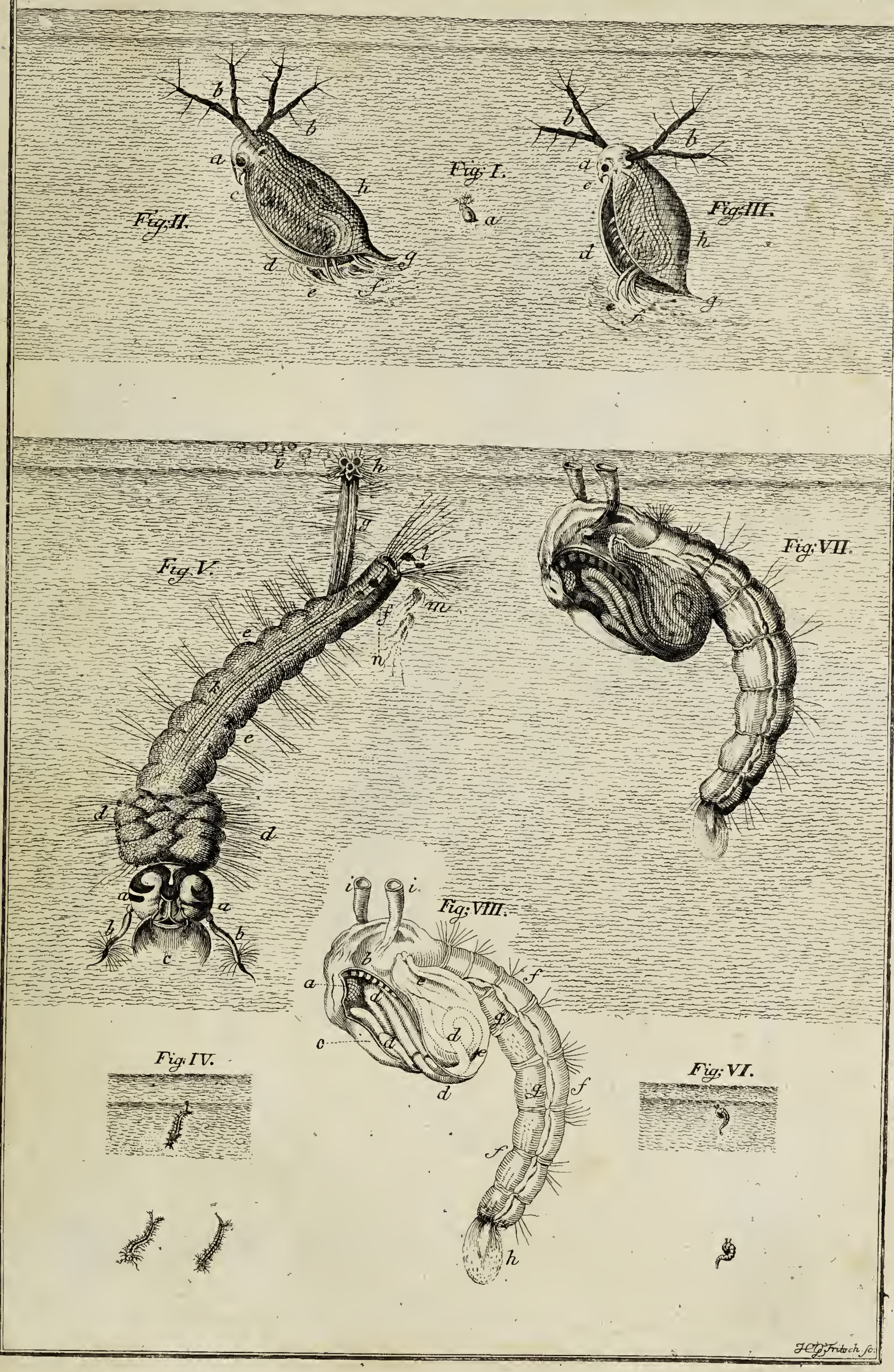
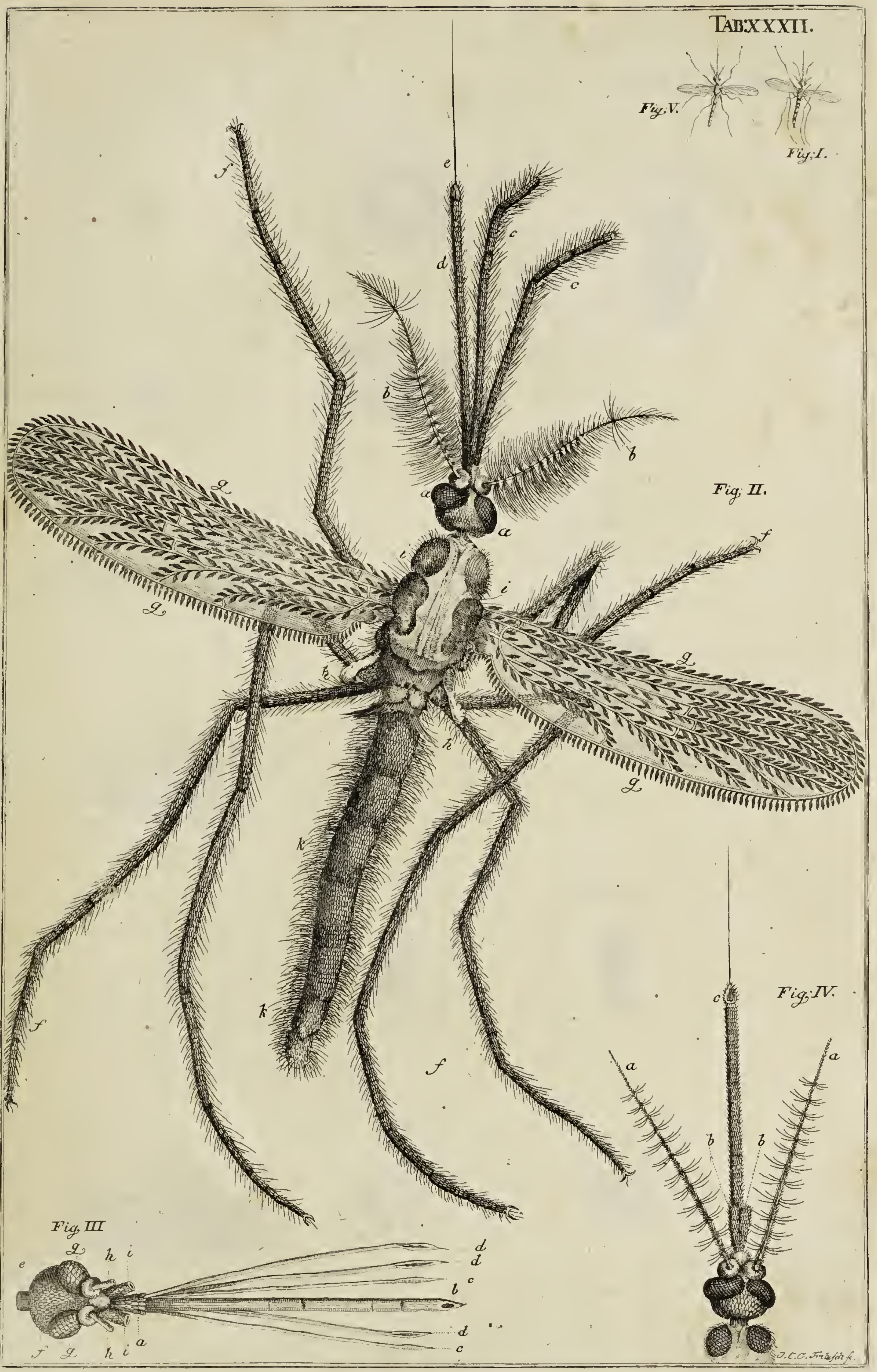


J.C.G. Fritsch ſc:

TAB. XXXII.



J.C.G. Fritzsch f.

Order the Third
Nymph Chrysalis or Aurelia

TAB. XXXIII.

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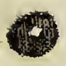

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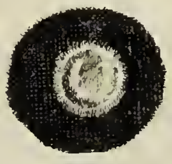

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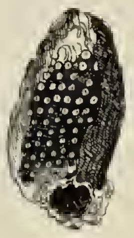

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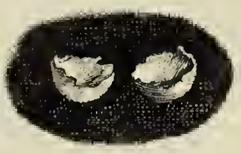

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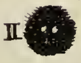

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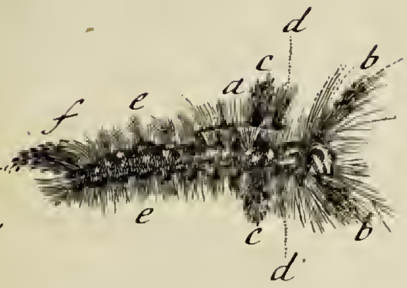

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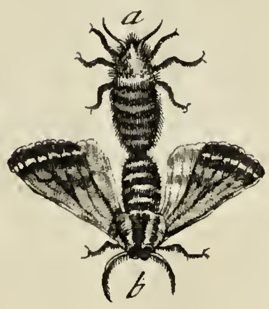

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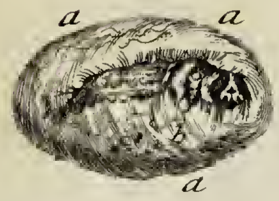

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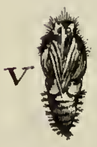

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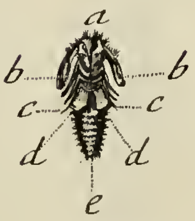

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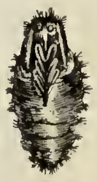

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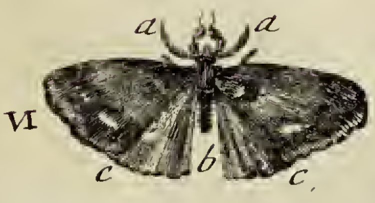

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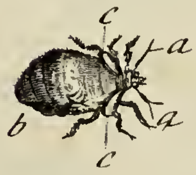

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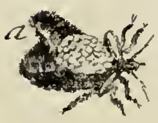

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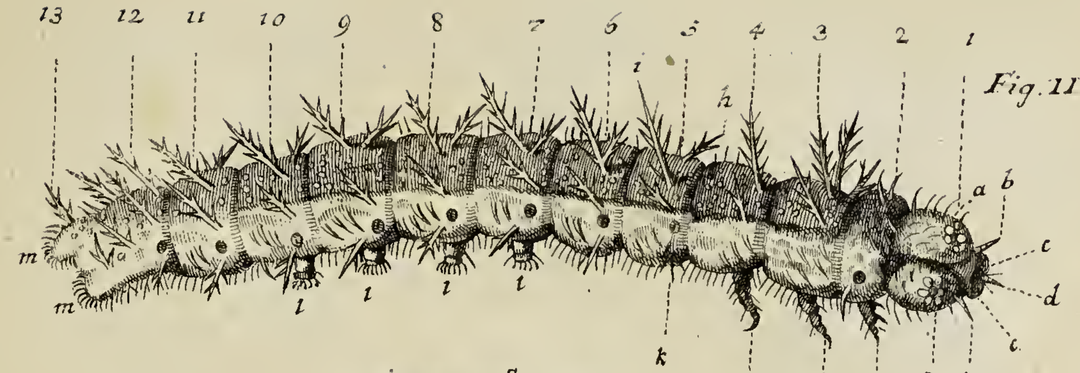

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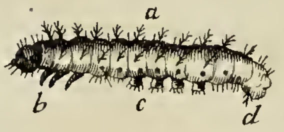

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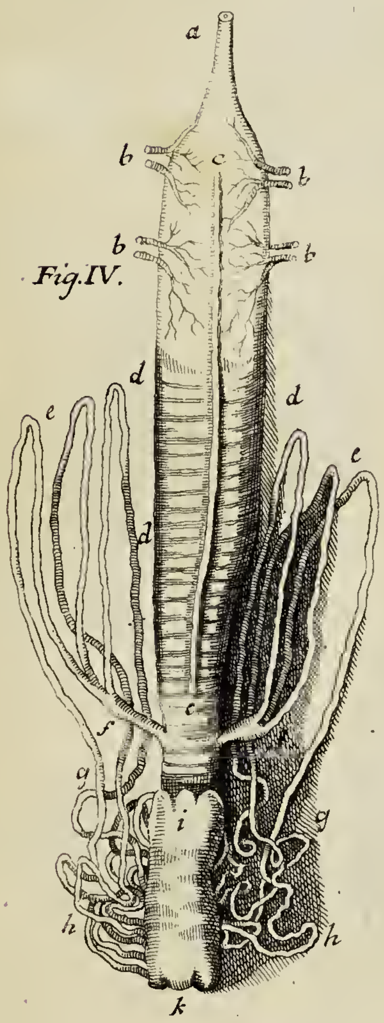

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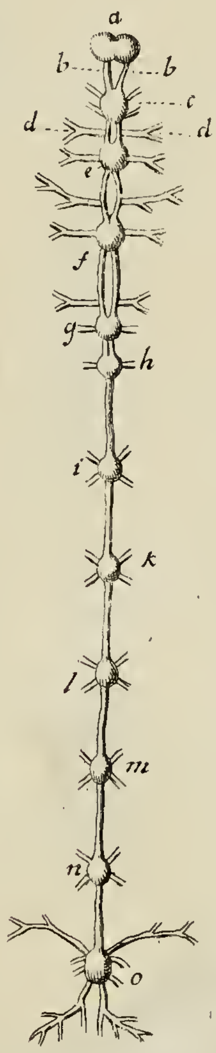

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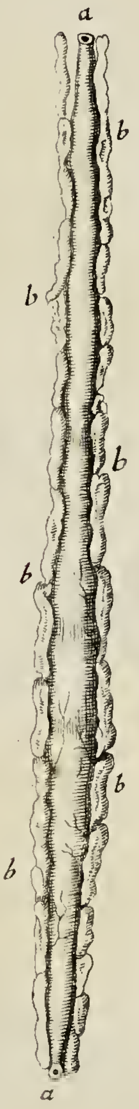
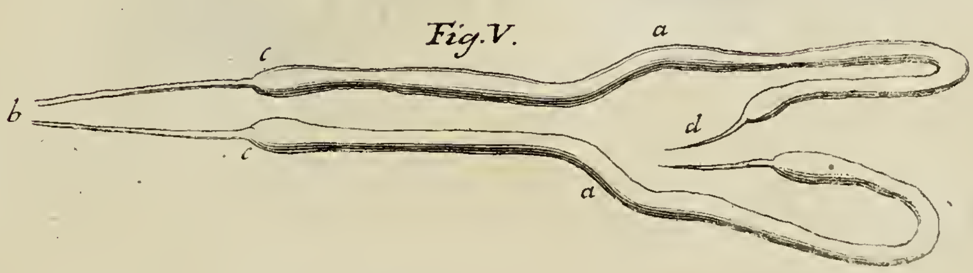


Fig. III.

Fig. V.



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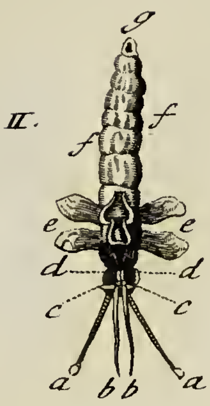

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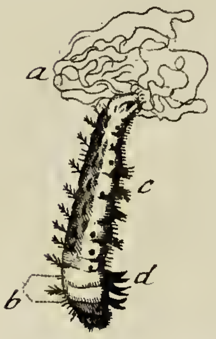

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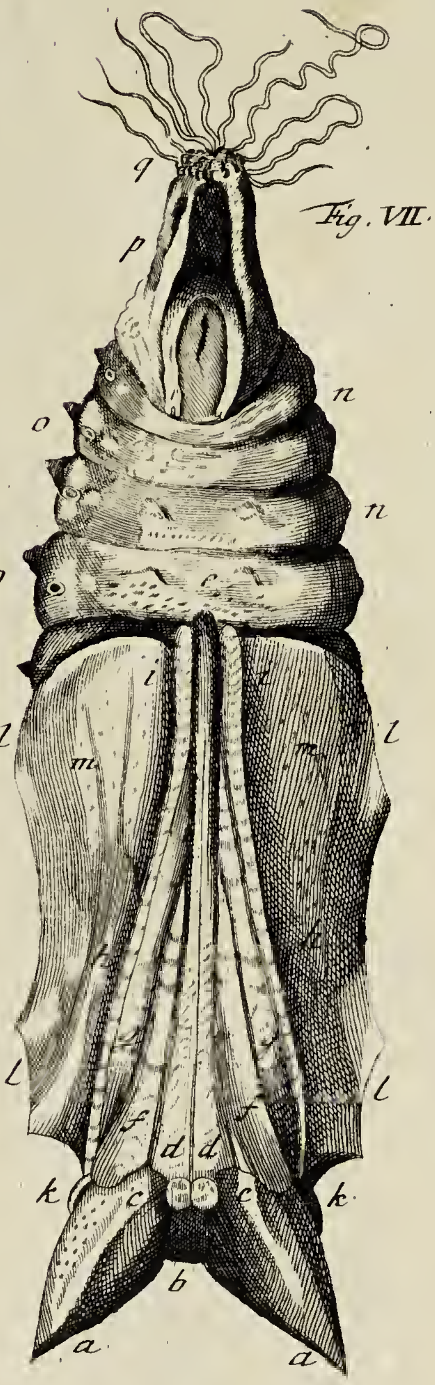

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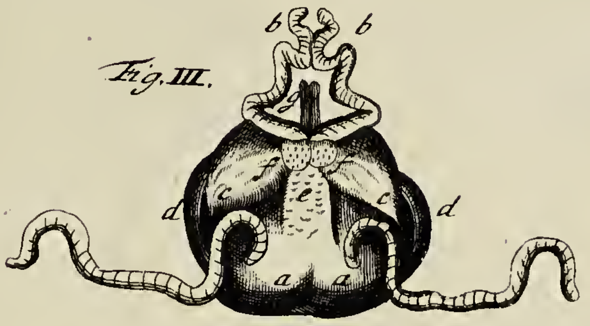

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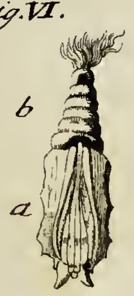

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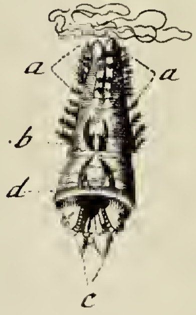

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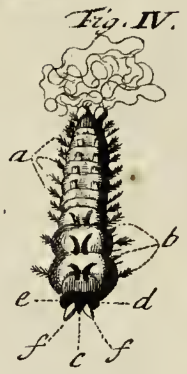

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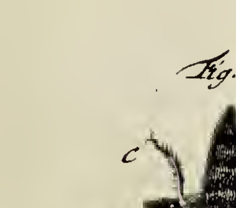

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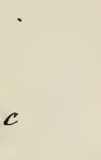

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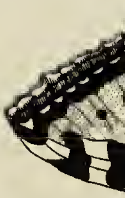

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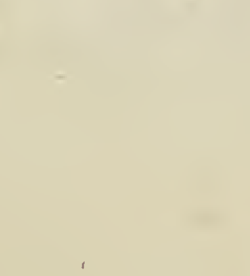

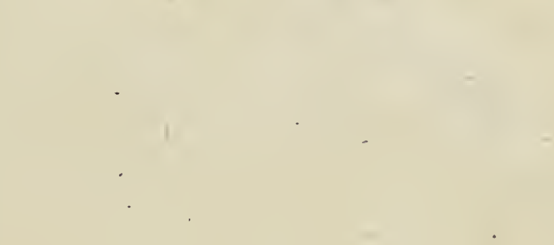

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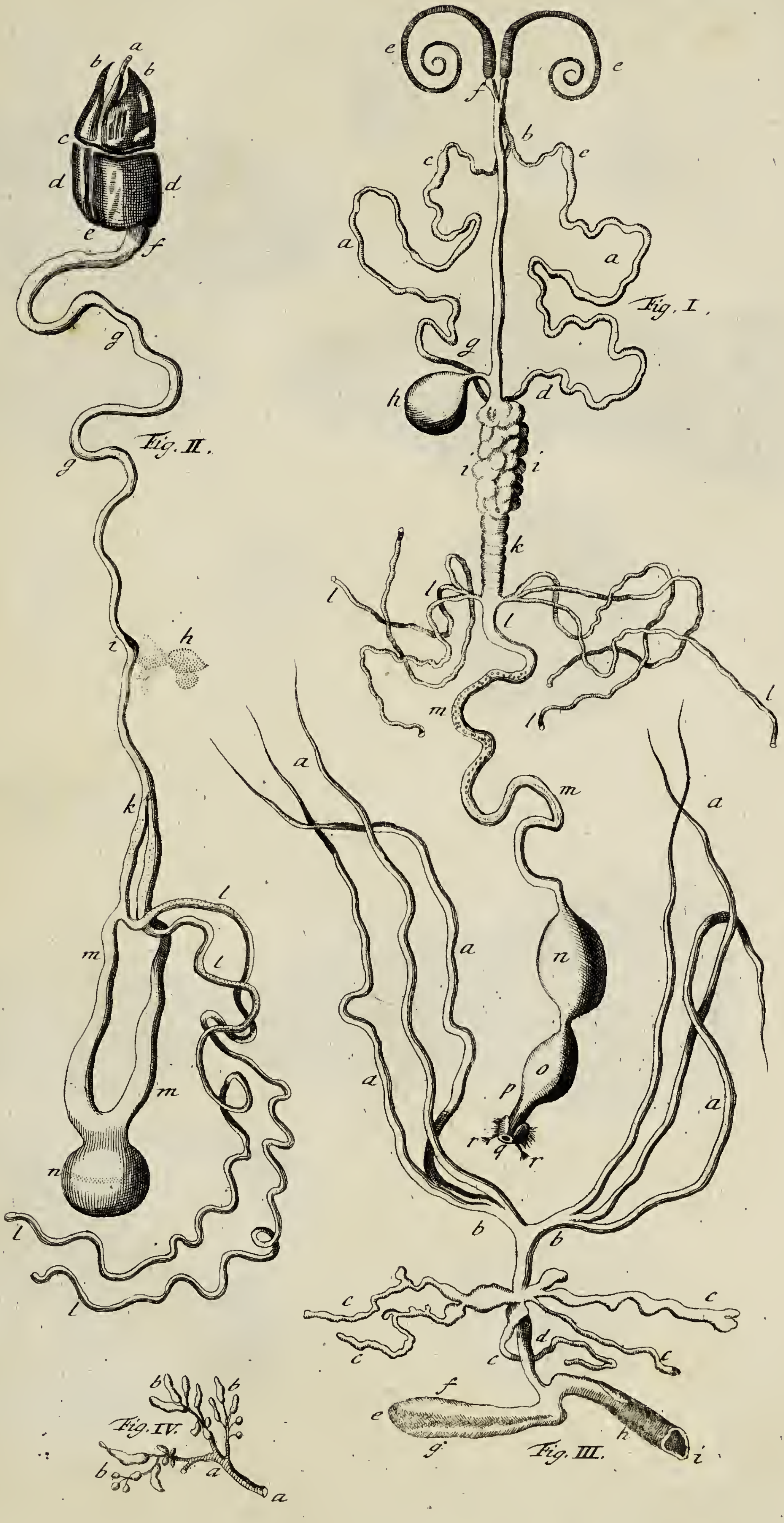
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Fig. III.
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Fig. IV.
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TAB: XXXVII.

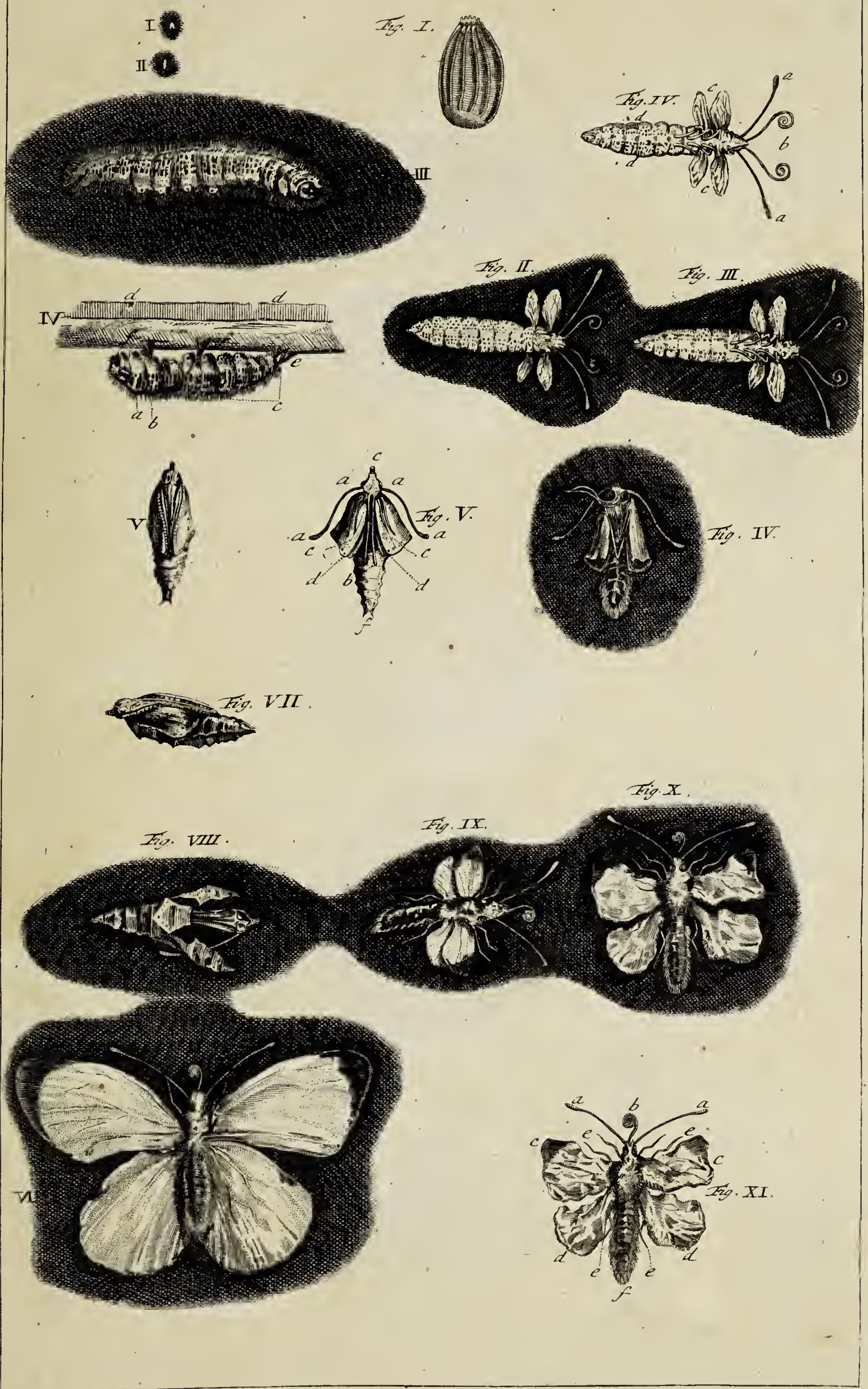
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Fig. I.
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Fig. V.
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Fig. VIII.
Fig. IX.
Fig. X.
Fig. XI.
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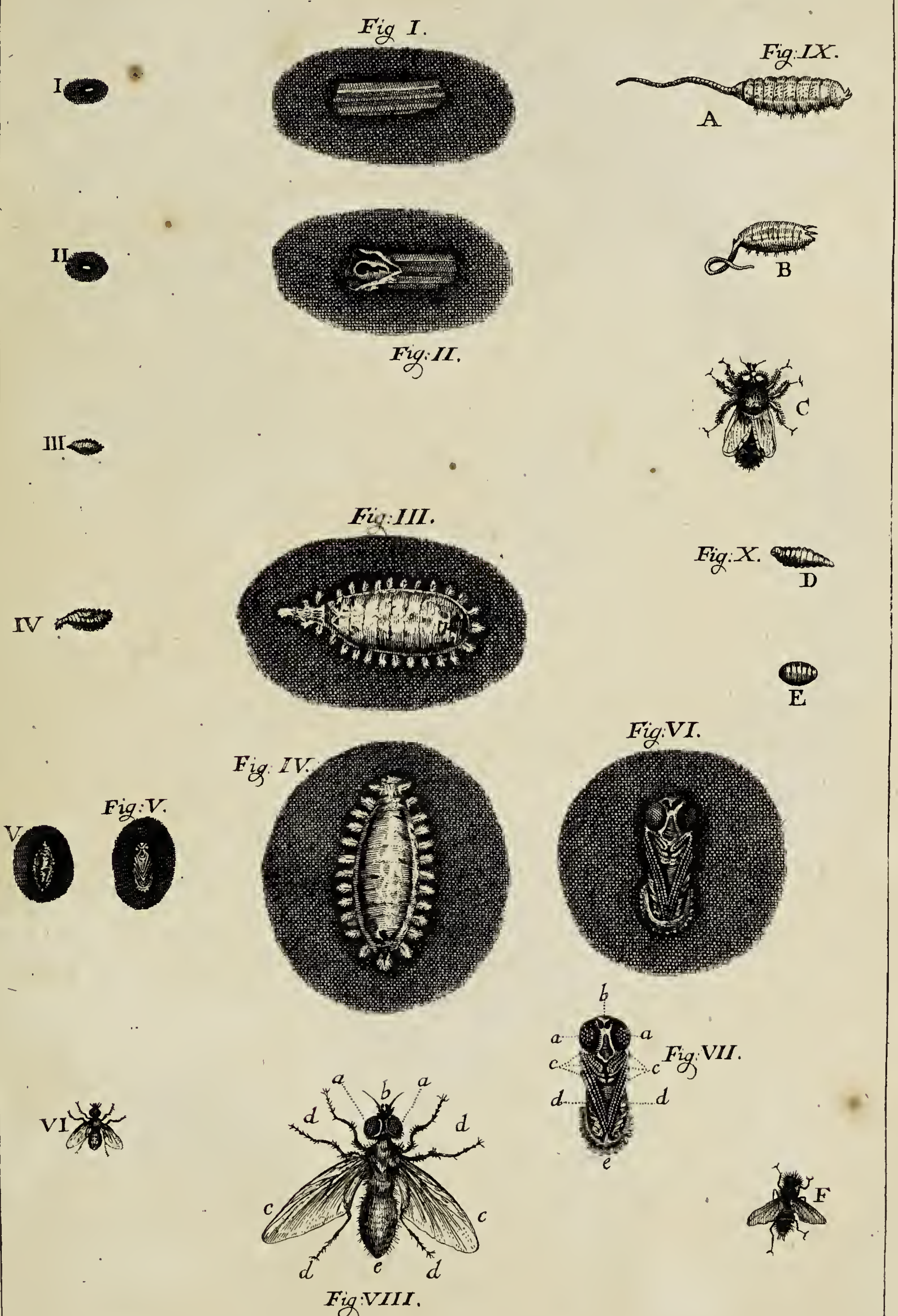
TAB: XXXVIII



J. C. G. Fritsch sc.

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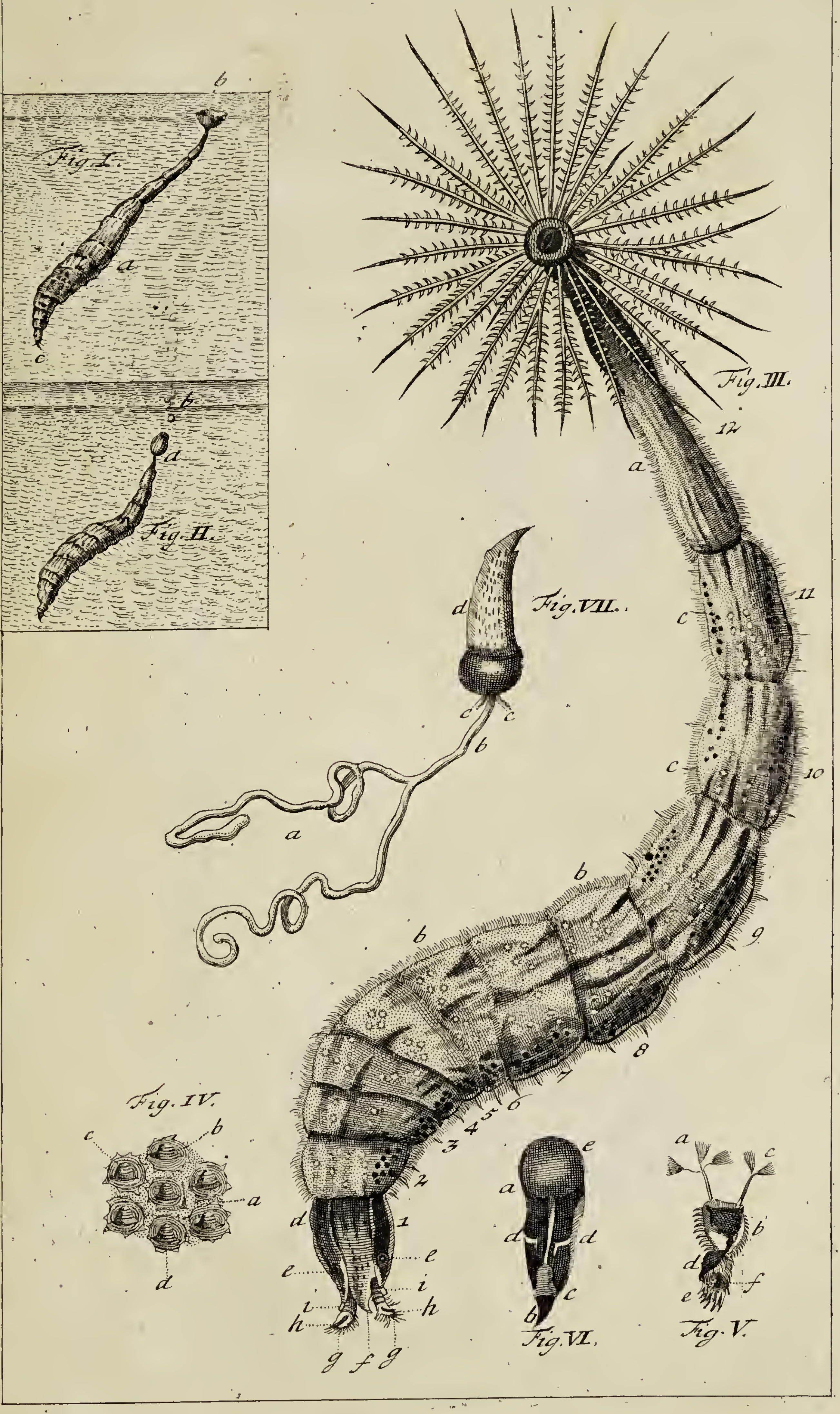
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Fig. II.
Fig. III.
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Fig. VII.
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Fig. VI.
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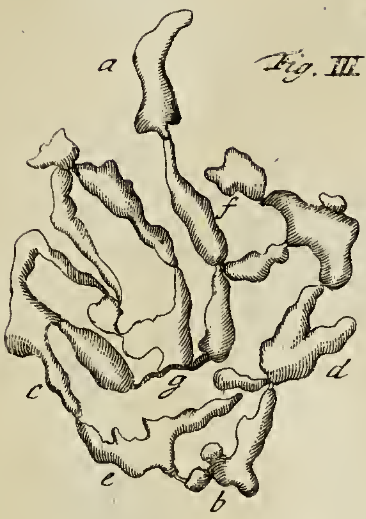
Fig. V.

TAB. XL.



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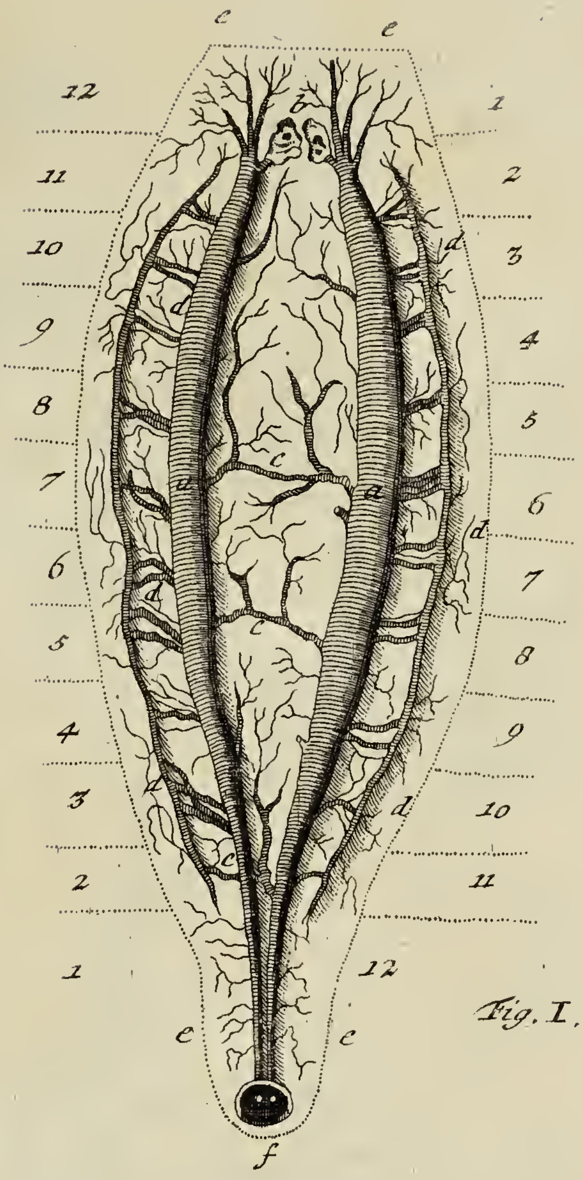

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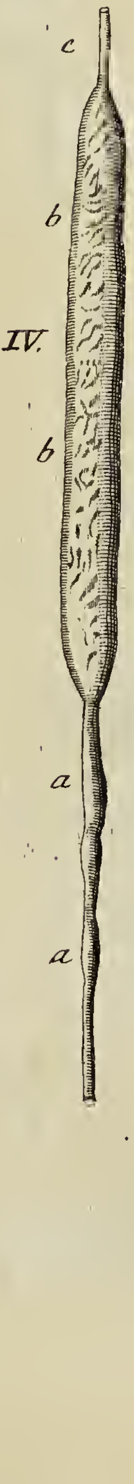

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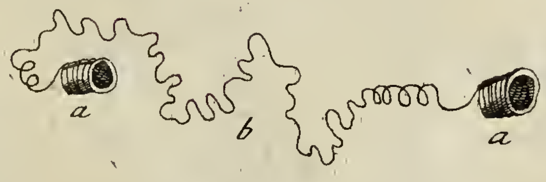

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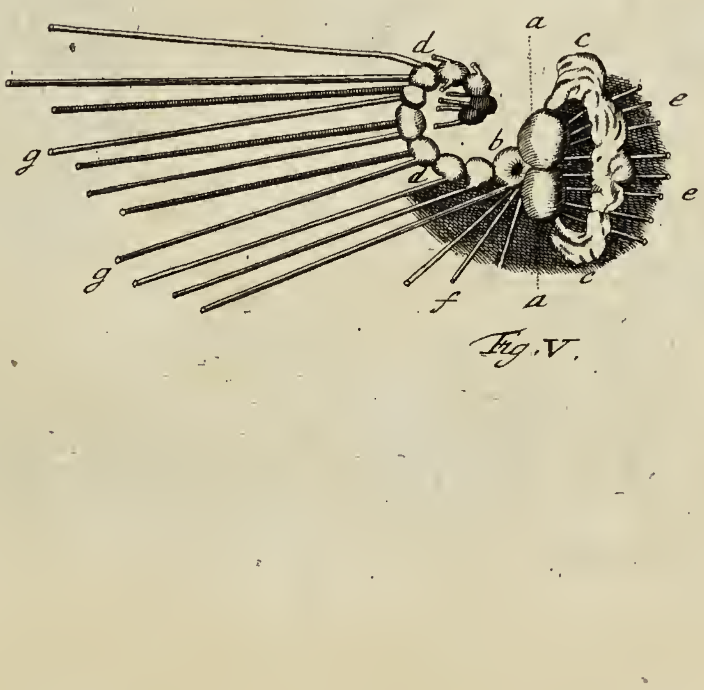

Fig. V.

TAB: XLI

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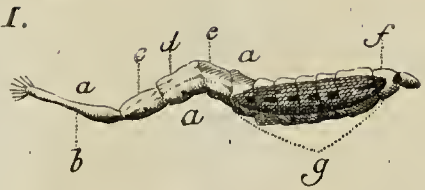

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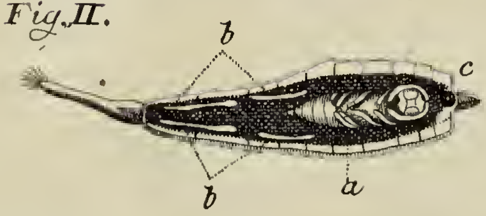

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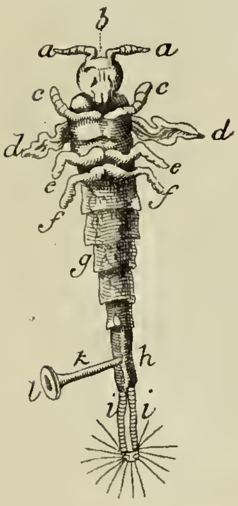

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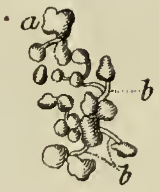

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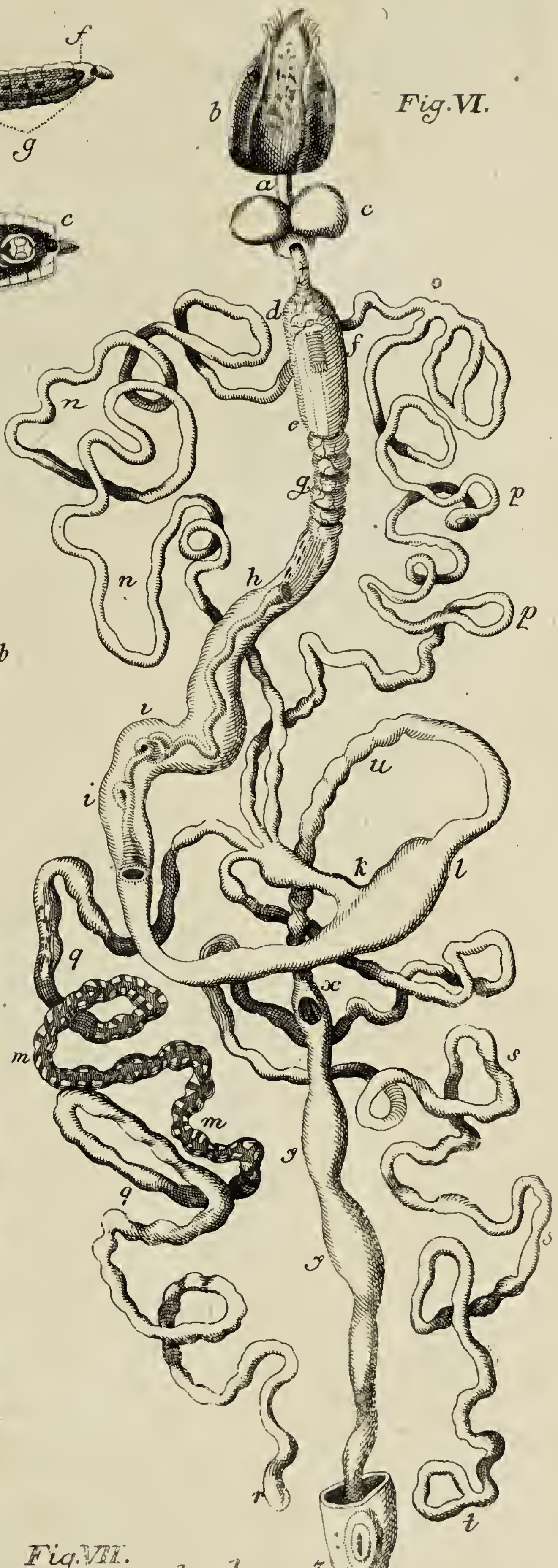

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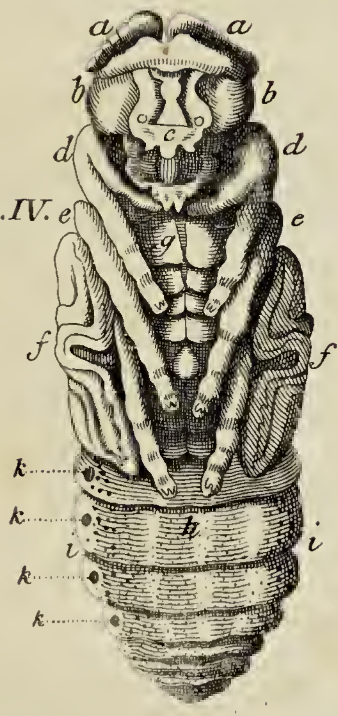

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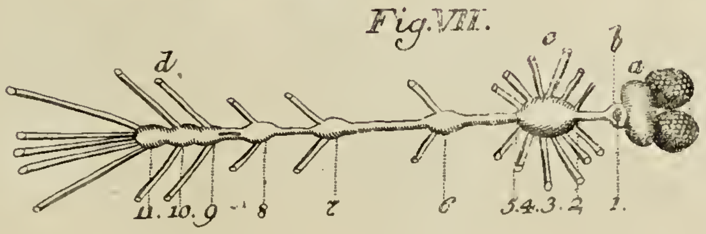

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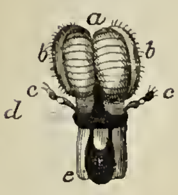

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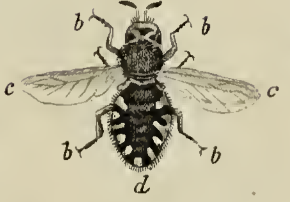

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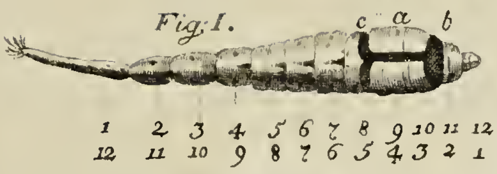

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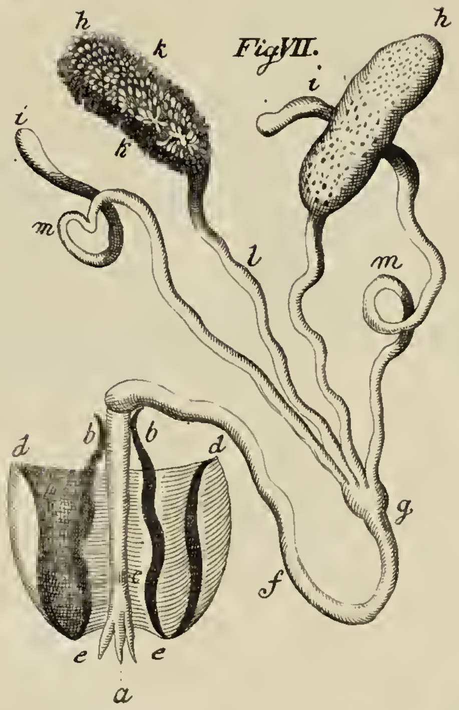

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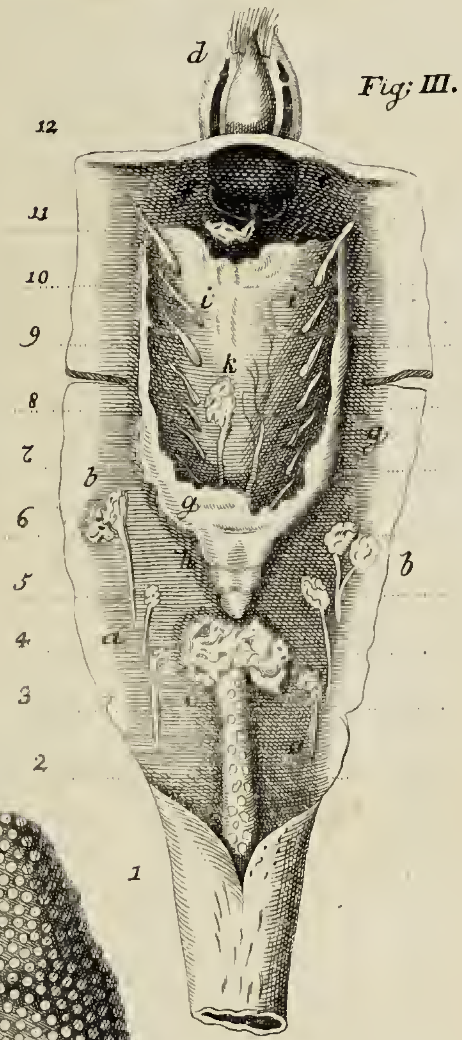

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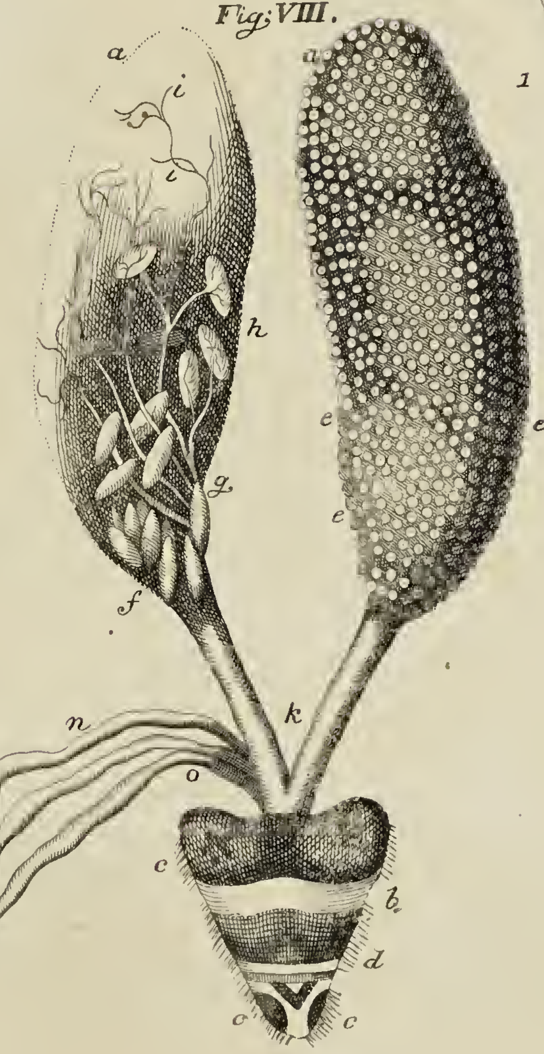

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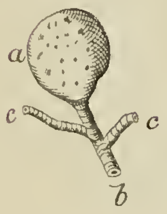

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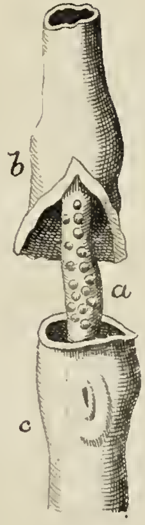

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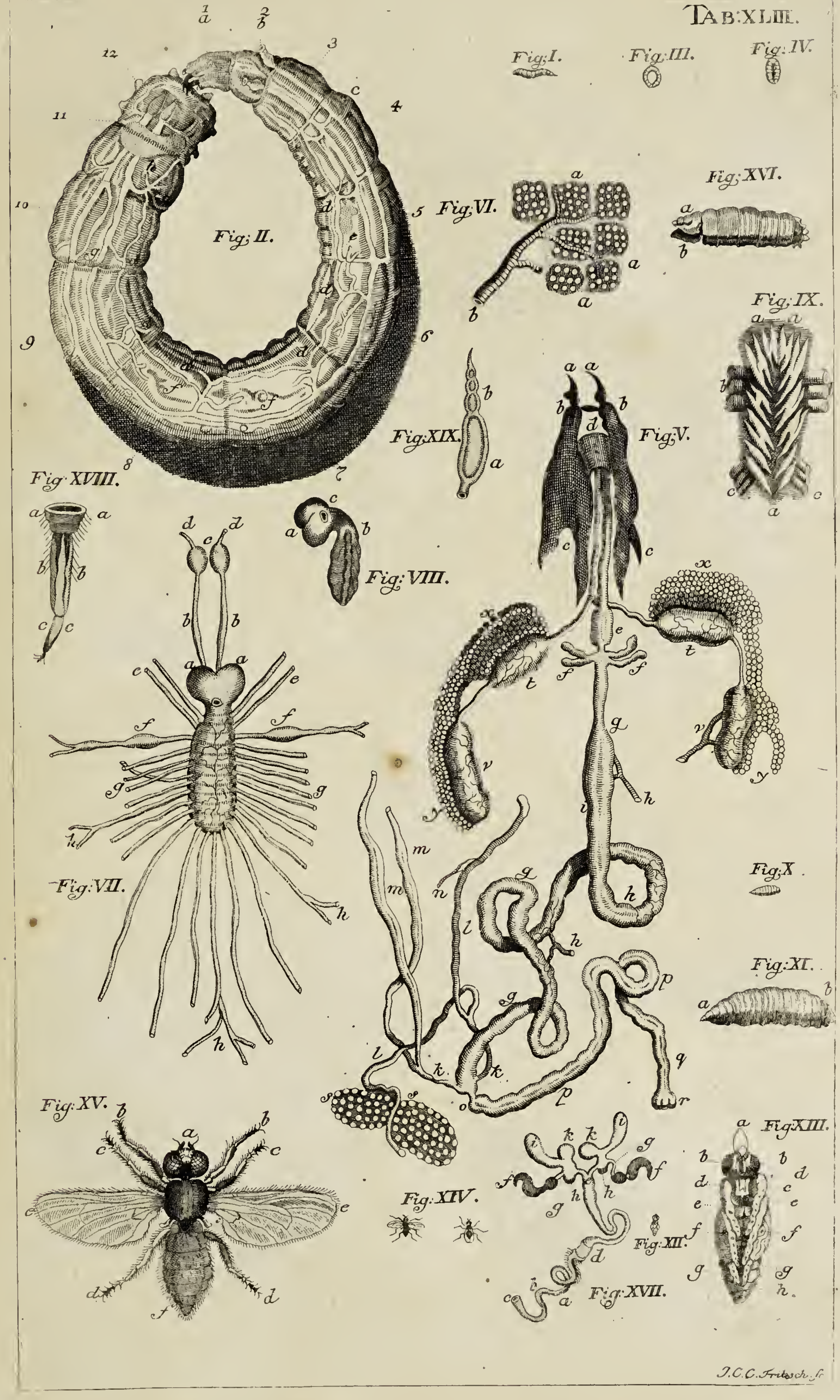
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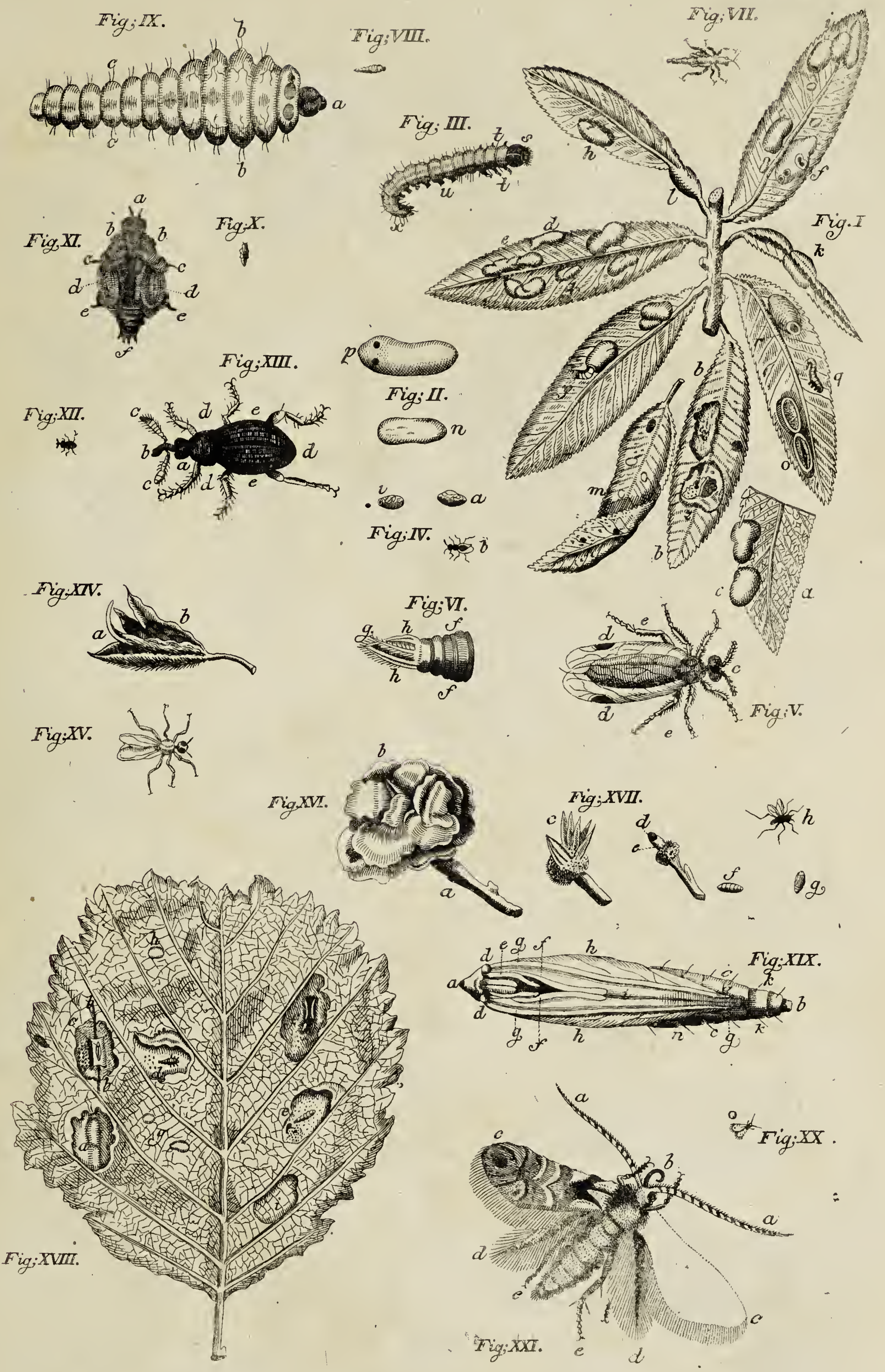
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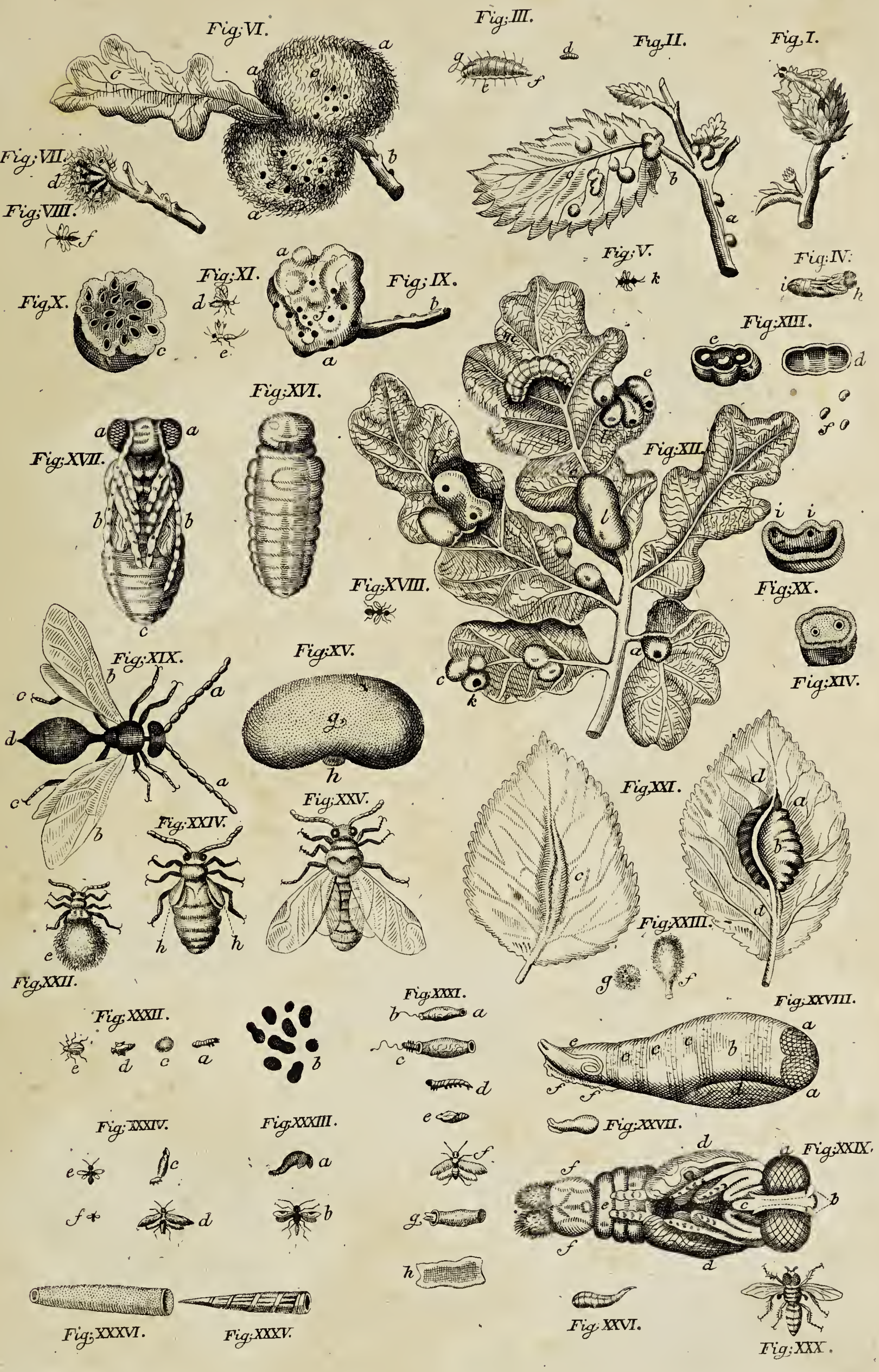

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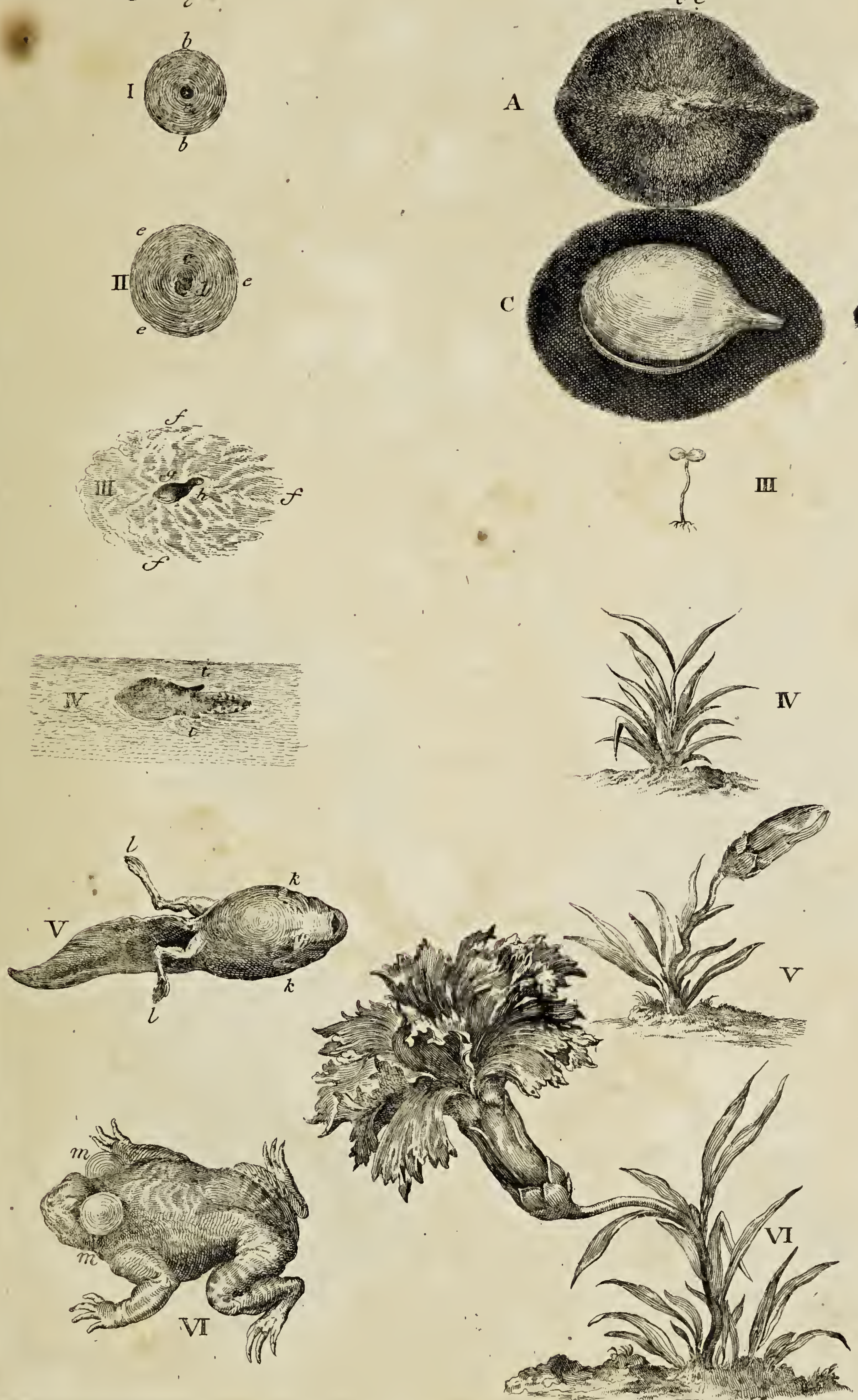

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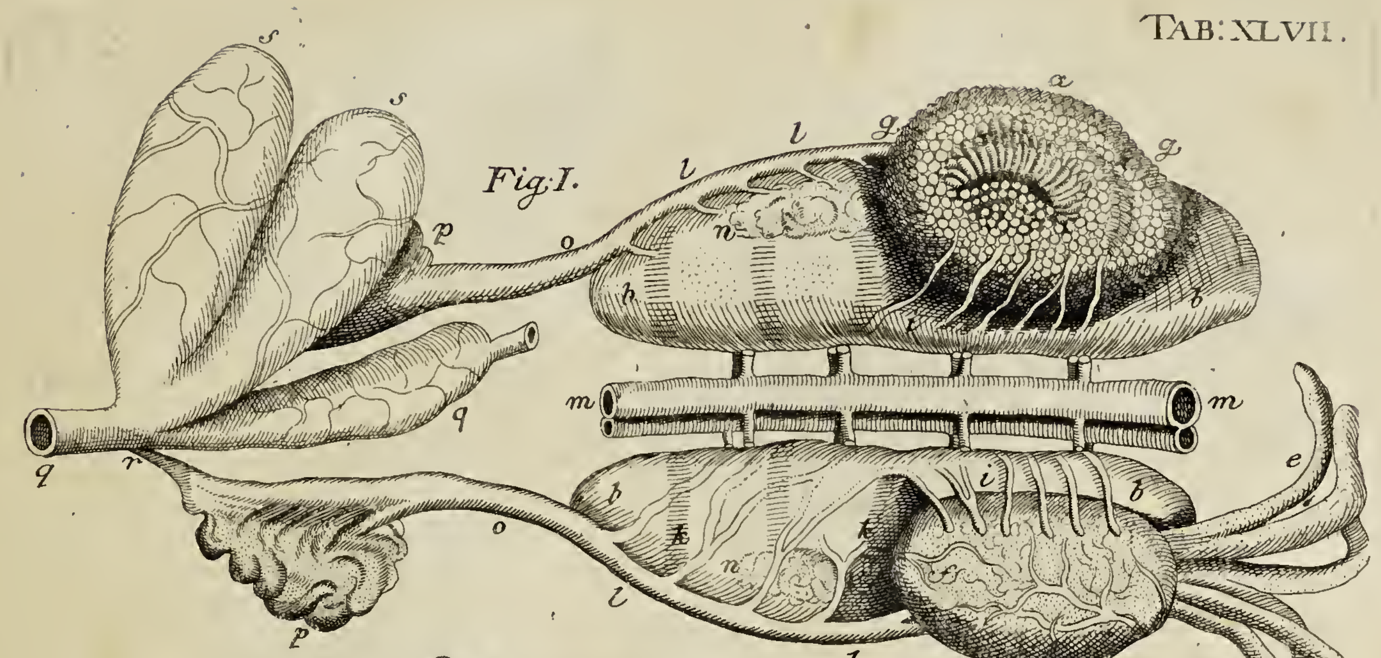

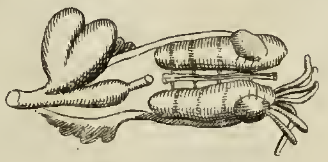

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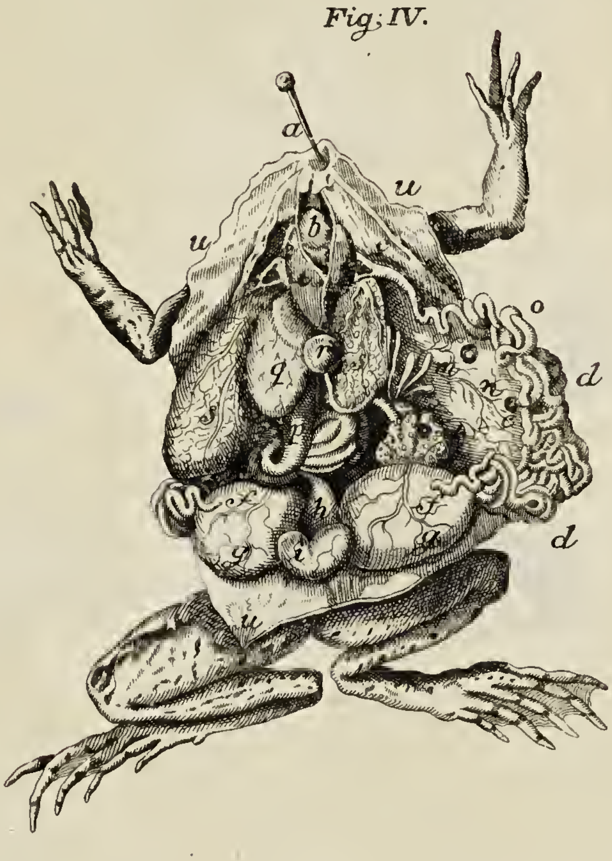

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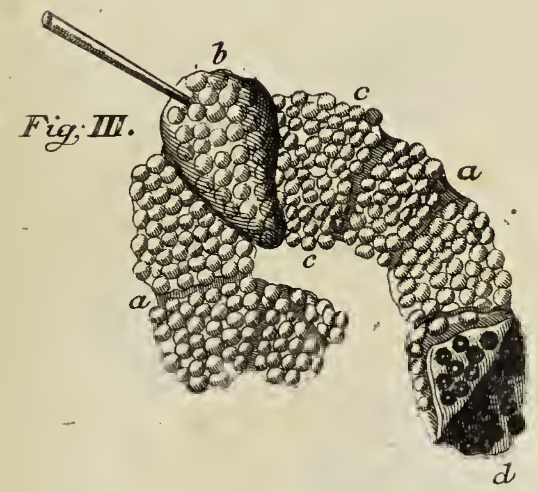

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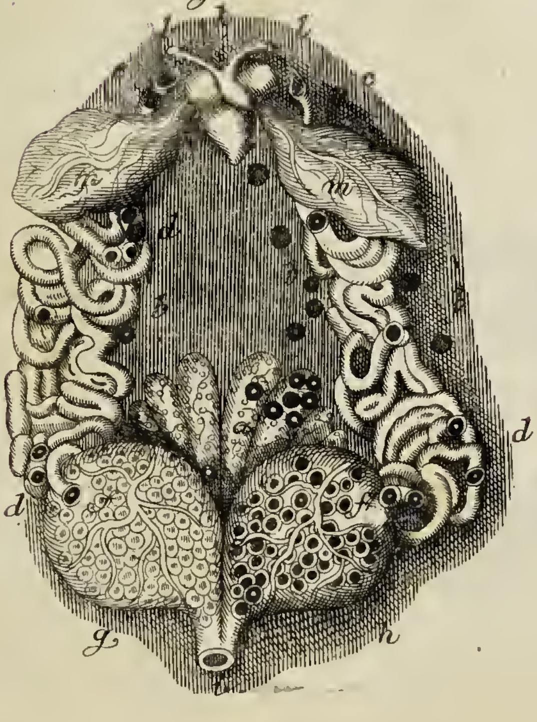

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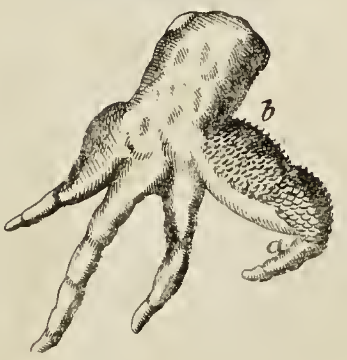

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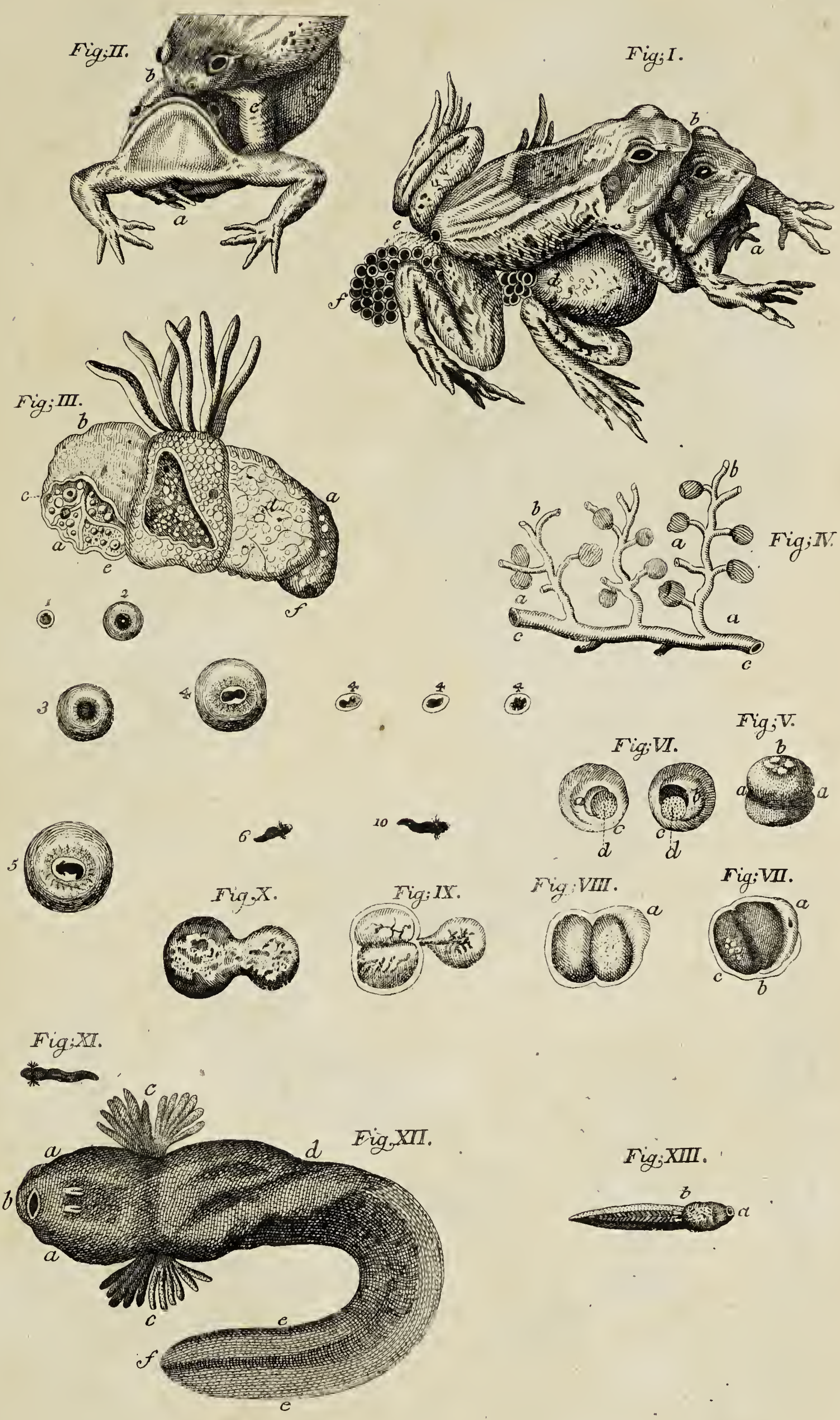
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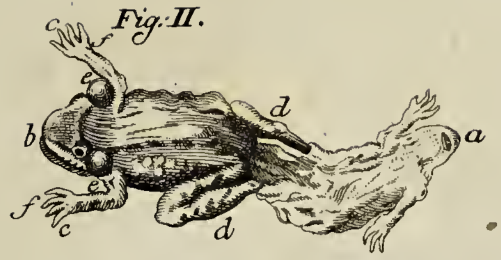

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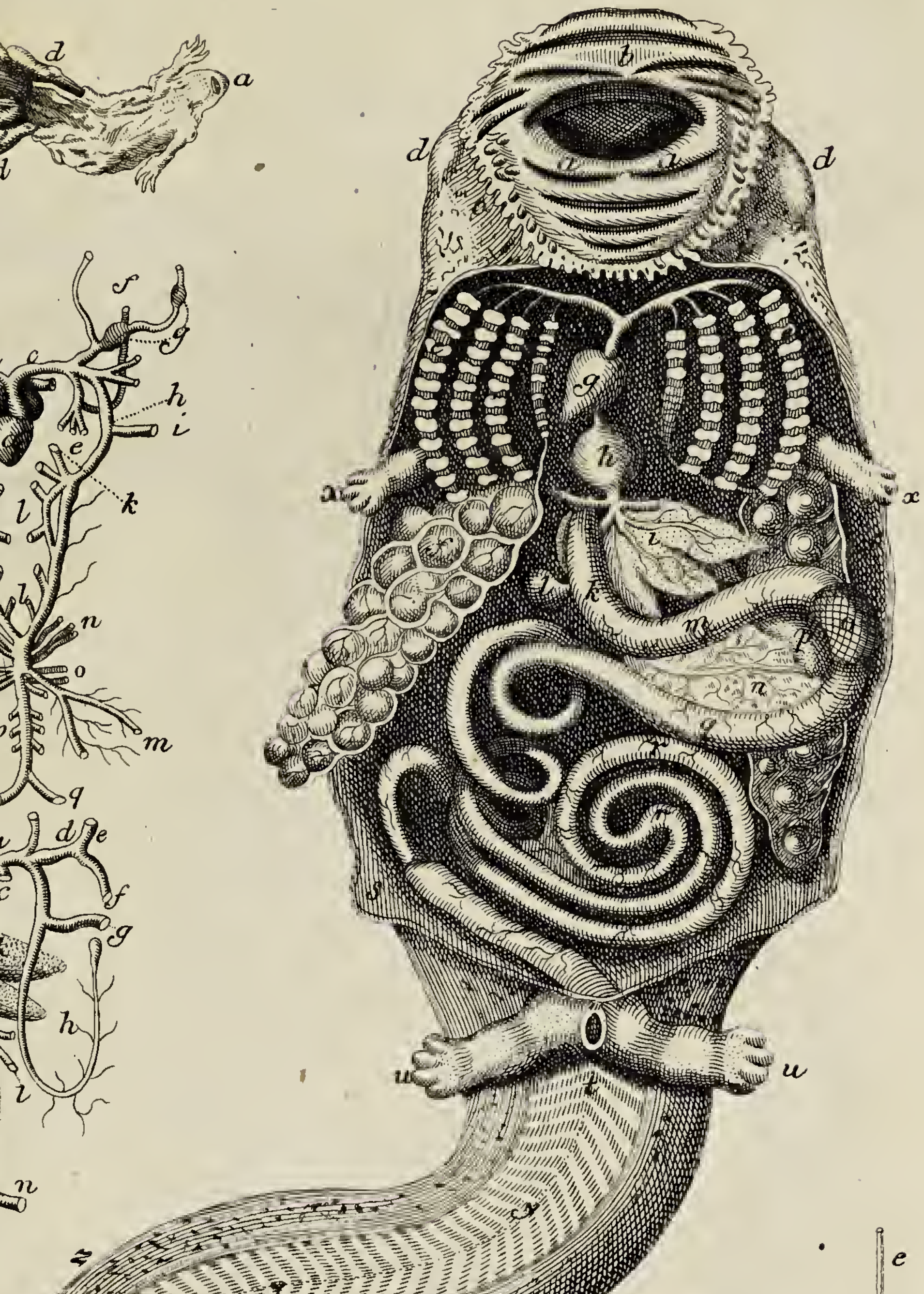

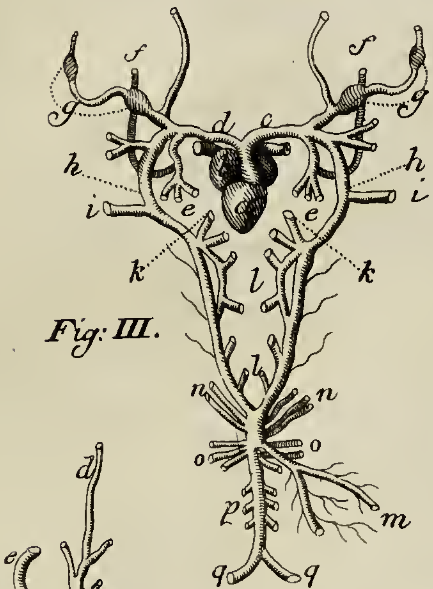

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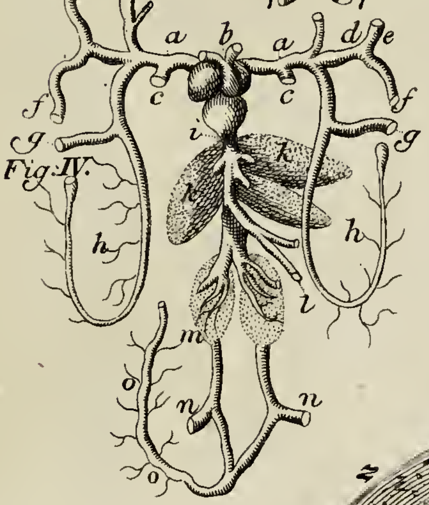

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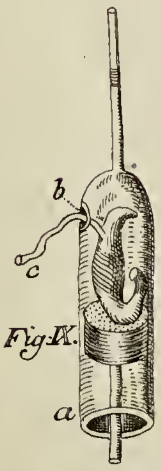

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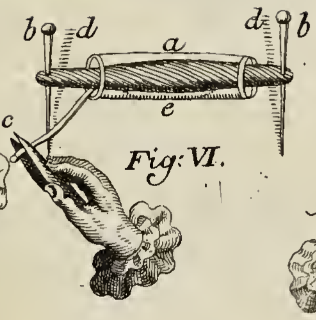

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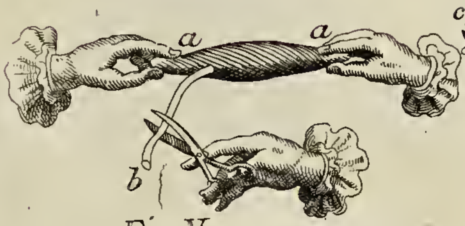

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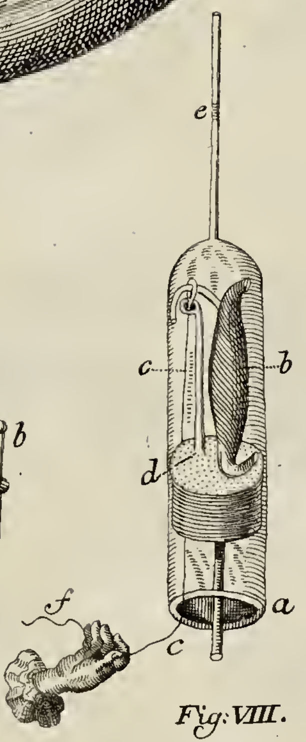

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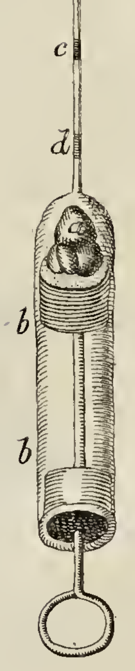

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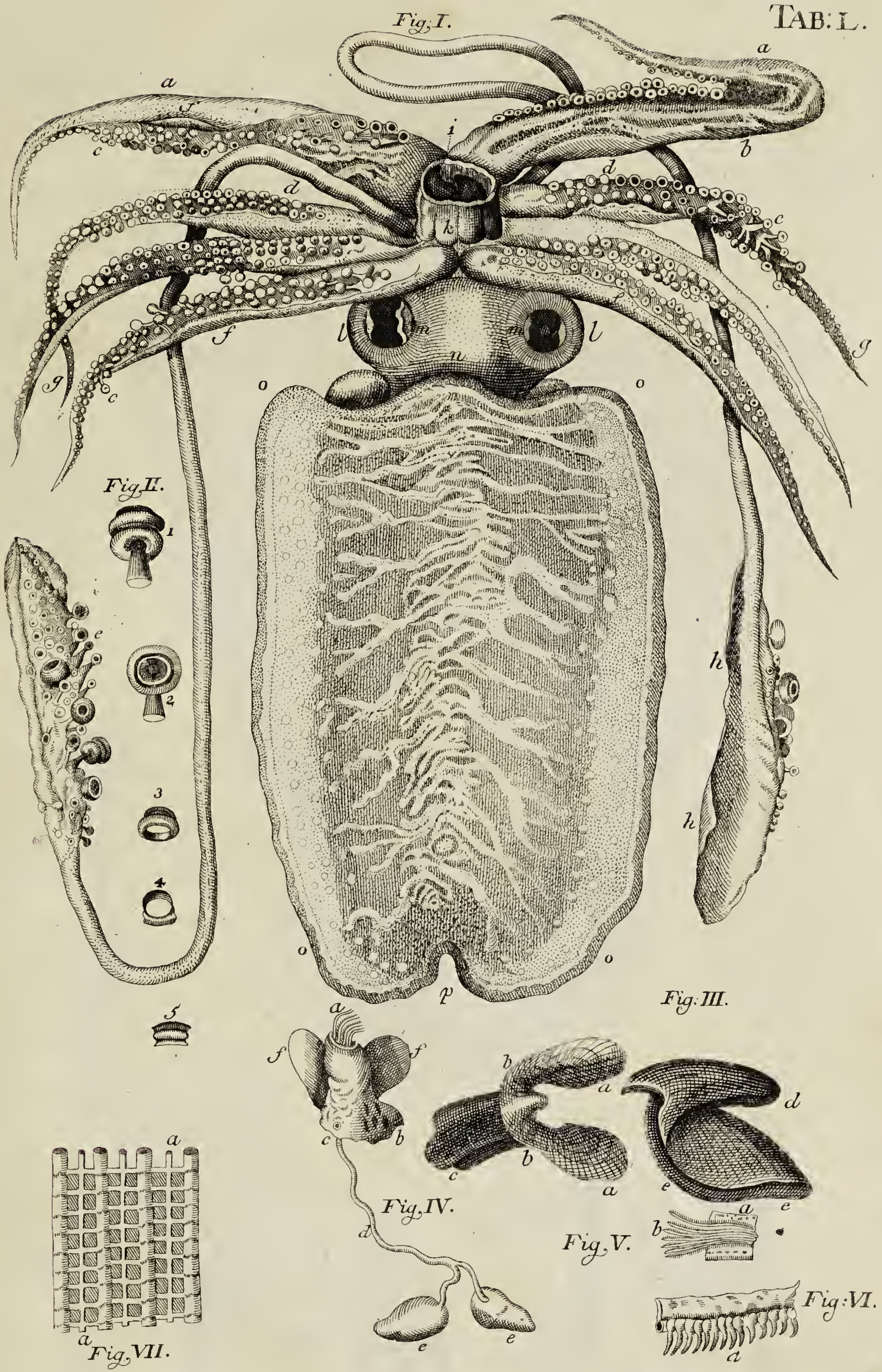
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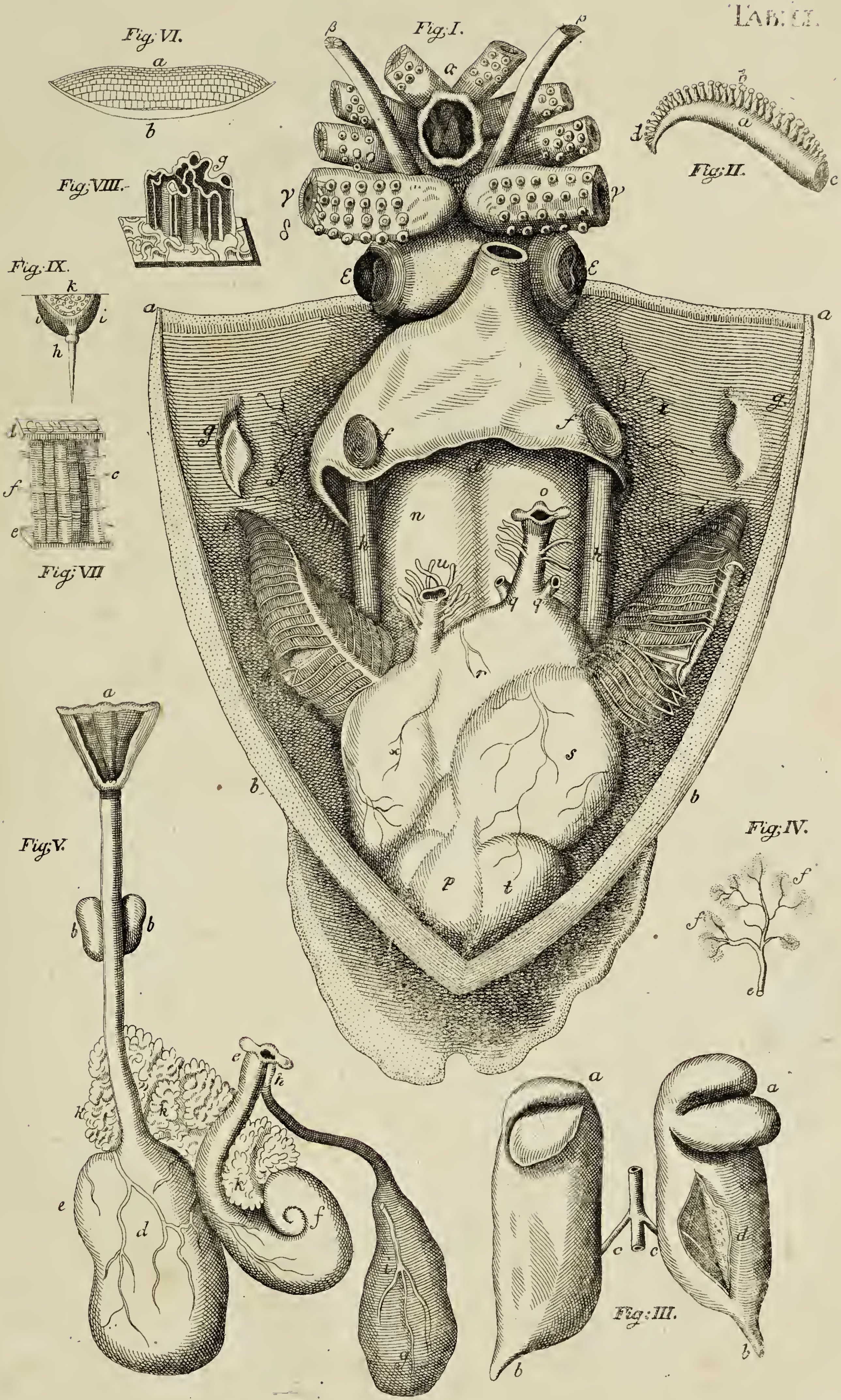
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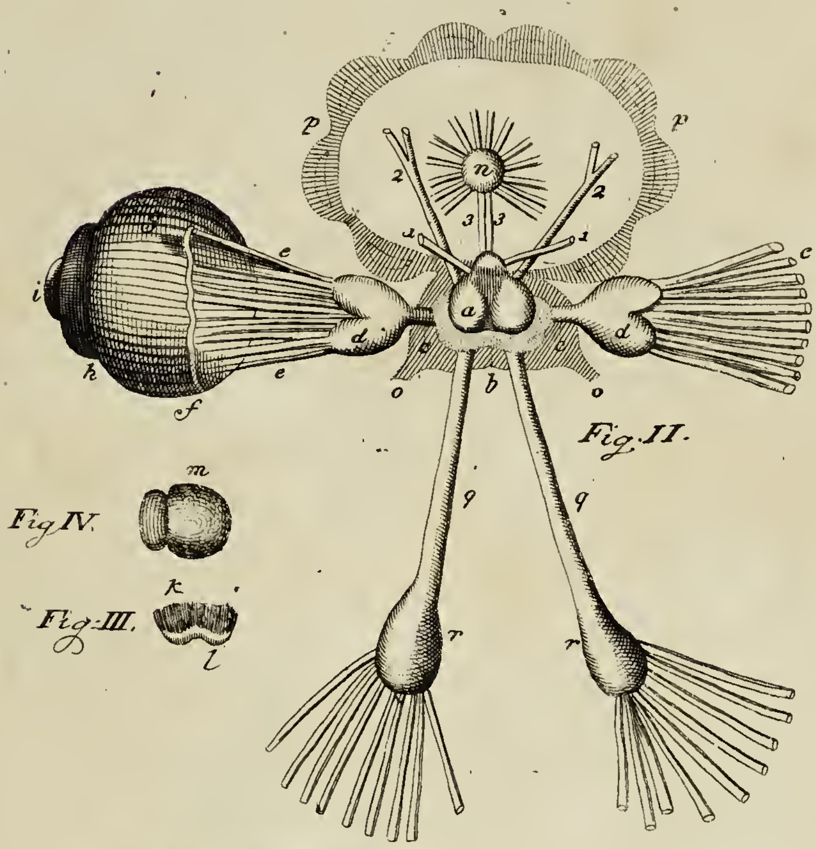

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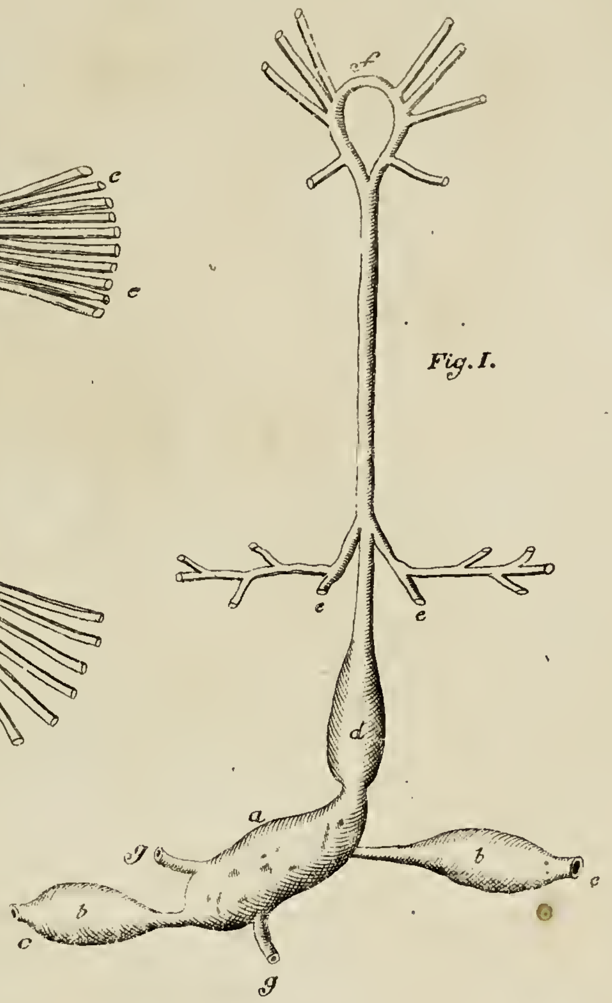

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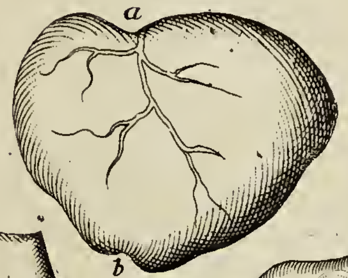

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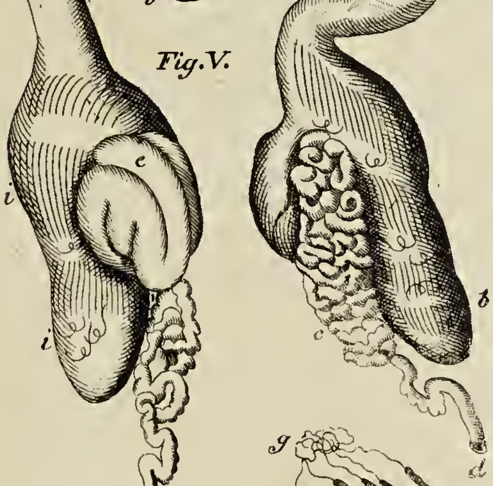

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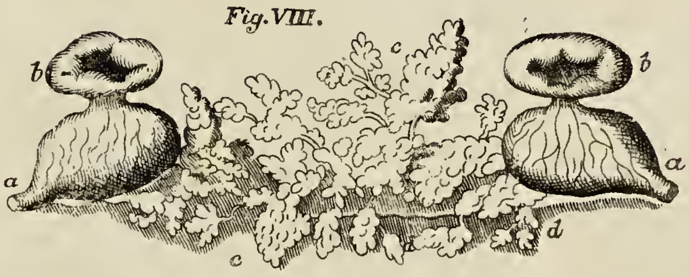

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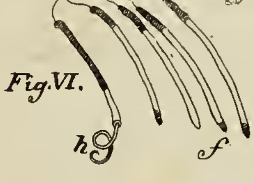

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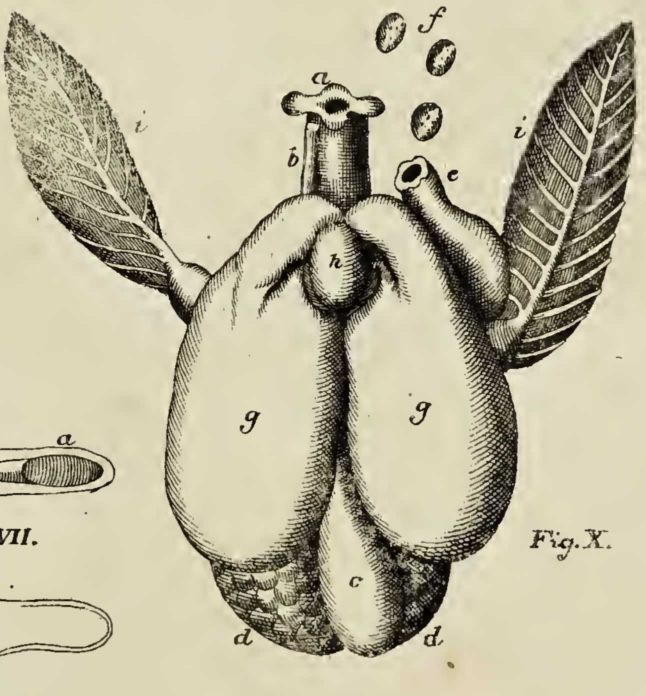

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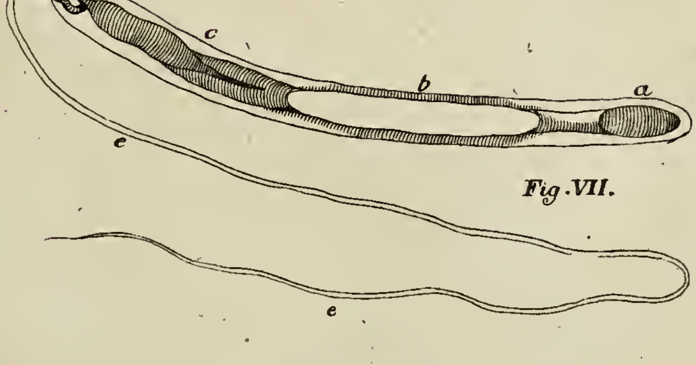

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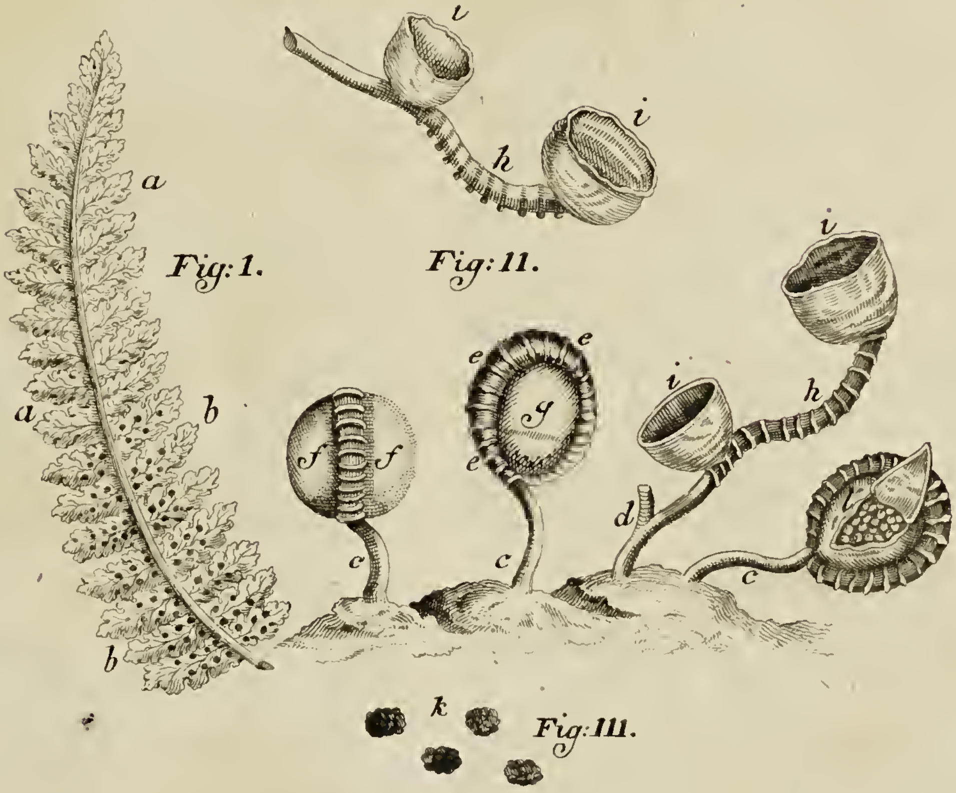

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The Reader is deſired to excuſe and correct the following ERRATA.

Page Col. Line	*Inſtead of*	*pleaſe to read*
31—2— 3	like a point	like a point *b*
32—1—44	of thoſe rings	of thoſe rings *f*
39—2—47	pidgeons	Pigeons.
46—2—34	ſtomach	ſtomach *b*
52—2—37	operculum	operculum Tab. IV. Fig. III. *m*
53—2—45	a little dilated,	a little dilated *g*
56—2—33	differens, which opens	defferens *b b* which opens
57—1—18	penis *e*	penis Fig. XX. *e*
60—1—54	the brain	the brain *c*
61— —44	bones	bone
63—1—45	Tab. IV.	Tab. VI.
65—2—29	halictations	habitations
67—1— 1	Stenon	Steno
—— —56	ſtretched out,	Stretched out *f*
69—1— 4	two upper ones	two upper *c c* ones
73—1— 8	divided ſkin	divided ſkin *c*
——2—10	tube	tube *z*
76—1—36	uterus	uterus *e*
77—2—31	ridge	ridge *b*
90—2—40	obſerved *b* ſeveral	obſerved ſeveral
98—1—50	Fig. I.	Fig. I. *a*
——2—11	wings	wings *d d*
100—2—54	Fig. VII.	Fig. VII. *a*
101— — 2	*belong*	*belongs*
102—1— 1	entraneous	extraneous
—— 2—48	middle *e*,	middle *c*,
104—1—29	1661	1671
108—1— 5	exuberant	extuberant
—— 2—21	Fig. IV.	Fig. IV. *f f*
109—2—58	this,	this *f*,
122—1—44	Panopes,	Panorpes,
132—1—51	Tab. XVII.	Tab. XXVII.
————40	varous	various
135—1—29	hairs,	hairs *f*,
136—1—37	Tab. XVII.	Tab. XXVII.
138—2— 8	the nerves	the nerves *d d d*
139—1—21	knot	knot *f*
140—1-laſt line but one	teeth	teeth *d d*
152—1—	after Fig. V. and VI.	blot out *b c* and *d*
163—1—7th line from the bottom	Delphos	Delft
P. II.		
11—1—33	head a	head and
53—1— 8	Hornius	Horne
141—1— 8	Stento	Steno
146—1—13	with	*l* with
149—2—26	fibres,	fibres *f*,

The Copper Plates are to be placed between the Explanation of the Tables and the Index.